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ON SOME AUSTRALIAN TERMITES OF THE GENERA DREPANOTERMES, HAMITERMES AND LEUCOTERMES.

By GERALD F. HILL, F.E.S.

(Plates IX-XII.)

This paper is intended as the first of a series in which it is proposed to record the results of an examination of a large collection of termites from various parts of the Australian continent. The greater part of this collection has been gathered in the northern districts of the Northern Territory, and in North Queensland, but during the past year it has been considerably increased by the addition of numerous small collections received from correspondents in Victoria, Western Australia and South Queensland, and now contains individuals from over 800 colonies. Through the courtesy of the authorities of the South Australian Museum I have been able to examine a number of co-type specimens which have been of the greatest assistance in clearing up many doubtful identifications. In addition to these, I have been able to study many species from localities not represented in my own collection.

For various reasons it has not been found practicable to study the species contained in these collections in systematic order; in many instances imagines, which are sometimes essential to satisfactory determination of species, are wanting; in others, reference to types or authenticated specimens of previously described species is necessary in order to obviate the possibility of creating synonymy. It is proposed, therefore, to deal with the various species more or less at random, leaving the preparation of a more comprehensive work until such time as our knowledge of the Australian termite fauna is much more complete than it is now.

Dr. Eric Mjöberg (1920) has recently added no less than 36 new species to those previously known from Australia and New Zealand, and has otherwise much increased our knowledge of the order. He lists 80 species, exclusive of some which have been too imperfectly described for identification, as comprising the termite fauna of Australia, Tasmania and New Zealand. To this list, however, should be added two old described species, *viz.*, *Calotermes convexus*, Walker, and *C. obscurus*, Walker, the types of which are still in existence, *Leucotermes paradoxus*, Frogg., and eight Northern Territory species described by me in 1915.

Eight new species, one new variety, and one hitherto unknown imago are described in the present paper, leaving at least 20 new species in the writer's collection to be dealt with. In addition to the latter number there are several species which cannot be satisfactorily described until more complete material is available for study.

A critical examination of a large collection of *Hamitermes*, *Drepanotermes*, *Leucotermes*, *Rhinotermes* and *Coptotermes*, has shown conclusively that in many species determinations cannot be made satisfactorily, if at all, from the soldier and worker castes alone. This fact will be made clear in this and subsequent papers.

Although aware of Fuller's recent paper (1920) on the antennae of termites, I have followed recent writers on the Australian species in regarding the number and form of the joints of this organ as possessing considerable taxonomic value. While due allowance must be made for the variations which certainly do exist in the antennae of nest-series, and not infrequently in the antennae of individuals, I see no reason at present for departing from the general practice of referring in some detail to antennal characters in descriptions of new species.

The wing measurements recorded in this paper were taken from the humeral suture to the apex. Head lengths, excepting where otherwise stated, are from the posterior margin of the head to the apex of the mandibles. Measurements are given in millimetres.

The type series, unless the contrary is stated, are in the author's collection.

***Drepanotermes silvestrii*, sp. n.**

Imago.—Head very dark brown, nearly black; postclypeus, thoracic, and abdominal tergites Brussels brown; lower surface chiefly antimony yellow; mid and hind tibiae, pleurae, and lateral blotches on abdominal sternites dark; wings dark brown.



Fig. 1. *Drepanotermes silvestrii*, sp. n., head and prothorax of imago.

Head (fig. 1) rounded behind, flat on the summit, glabrous, moderately setose, Labrum moderately large, swollen on the sides, rounded in front. Anteclypeus, membranous, pointed in front. Postclypeus rather larger than in *D. rubriceps*, Frogg., twice as wide as long. Eyes small, nearly circular (0.329×0.376), slightly projecting. Ocelli large, oval, oblique, well separated from the eyes, anterior margin in line with anterior margin of eyes. A small deep impression on either side between the ocelli and clypeus. Fontanelle large, broadly oval, very distinctly visible, with small indistinct forward extension. Antennae 18-jointed, not variable in size and shape of segments; 1st joint long, stout, cylindrical, more than twice as long as wide; 2nd three-fifths the length and two-thirds the width of 1st; 3rd and 4th very short, shortest of all, narrower than 2nd, coalesced; 5th short but distinctly longer and wider than 3rd and 4th; 6th longer and wider than 5th; 7th, 8th and 9th equal; 10th longer than 9th; 11th to 15th about equal; 16th and 17th a little longer and narrower, 17th narrower than 11th to 16th; 18th as wide as, but longer than 17th, as long as 1st, pointed.



Fig. 2. *Drepanotermes silvestrii*, sp. n., hind tarsus of imago.

Prothorax (fig. 1) nearly flat, slightly sinuate and bent up in front, antero-lateral angles rounded, sides rounded to the rounded posterior margin, moderately setose. Meso- and metathorax uniform brown, wing-stumps similar to those of *D. rubriceps* but smaller. Legs (fig. 2) very long and slender, armature alike in each excepting that the first tibiae bear the usual additional spur; fourth tarsal of each leg very long and slender; femora all about equally stout.

Wings (fig. 3) with the margin ciliate, membrane with very few hairs; dark brown, a little lighter on costal border; subcosta very short, hardly extending beyond suture; costa and radius well separated, the latter very dark, joining the former near the apex, sometimes giving off beyond the middle numerous small veinlets to the costa; median of the fore-wing branching from the radius within the wing-stump, moderately thick at the base, nearer to the cubitus than to the radius, branching very irregularly, sometimes dividing into two before the middle and each branching again into two or three, the main superior branch joining the radius near the distal end of the latter or bending downwards and joining the wing margin at or very near the apex, if the former, a number of small cells are formed beyond the junction; sometimes the branches are all curved downwards and reach the hind margin below the apex. There is always a network of veinlets between the median and radius. The median vein of hind-wing branches from the radius beyond the suture, but otherwise it is like that of the fore-wing; sometimes there is an inferior branch near the base which joins the cubitus about the proximal third of the wing; sometimes this branch joins the second one and forms a large elongate cell, or there may be a succession of cells of varying shape and size. The cubitus of the fore-wing has from 10 to 16 branches, forked or simple, all of which join the hind margin before the distal fourth or fifth of the wing; that of the hind wing has from seven to nine simple or forked branches, the first five to seven of which are much darker than the others.

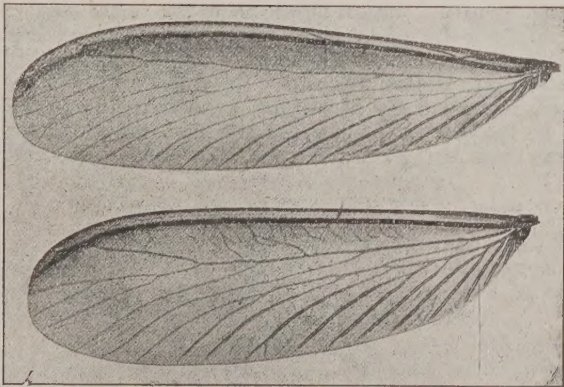


Fig. 3. *Drepanotermes silvestrii*, sp. n., wings of imago.

Abdomen large, distended, with eight distinct broad dark tergites, clothed with short fine hairs, and with apical and lateral margins fringed with longer yellow hairs. Ventral surface of female with six visible yellow-ochre sternites, each with dark lateral blotches, the fifth longer than the preceding ones, but much shorter than the sixth. The male has eight distinct sternites, the fifth and sixth longest, the seventh much shorter and narrower, the eighth shortest and very narrow. Cerci short and stout. Styli absent in both sexes.

Measurements*: Length with wings, 19-20; length without wings, 11; head, with mandibles, 2.16 long; head, at and including eyes, 1.7 wide; antennae, 3; mandibles, right, 0.92-1.03 long, 0.7-0.75 wide; left, 1.03-1.08 long, 0.62-0.65 wide; prothorax, 0.94 long, 1.64-1.78 wide; forewings, 15-16 long, 4 wide; hindwings, 14.5 long, 4.5 wide; tibia (i) 1.42, (ii) 1.55, (iii) 2.11; abdomen, 2.75 wide.

* Given in millimetres.

Queen.—Antennae generally complete, *i.e.*, 18-jointed; wing-stumps often mutilated; two or three legs generally amputated, claws of remaining legs short and blunt, apices of second and third tarsi heavily chitinised. Eight dorsal and six ventral abdominal plates distinct; pleurae and integument cream-coloured. Abdomen 16 long by 6 wide. Other characters as in imago.

King.—Uniformly dark above; abdomen much contracted and plates overlapping; pleurae obscured by dorsal and ventral plates. Other characters as in queen and imago. One specimen examined; apparently very old; associated with two old neoteinic queens.

Neoteinic Queen.—Head and clypeus yellow-ochre, prothorax a little lighter; tergites and sternites amber-yellow, the latter with wearing surfaces dark and heavily chitinised, pleurae and spaces between plates cream-coloured. Head wide; eyes small, hardly projecting, only inner facets pigmented; ocelli as in imago; fontanelle a large oval cavity about as large as and shaped like eye (in nymphs of the first form it is much smaller and proportionately more elongate, as in adult); antennae 17-jointed, apparently never mutilated, third and fourth joints fused, short; prothorax shaped as in imago; wing-buds long, slender, subequal, three-fifths length of the entire sclerite. Abdomen with cuticle horizontally striate.

Measurements: Head, at and including eyes, 1.70 wide; prothorax, 0.94 long, 1.60 wide.

Described from two old individuals found in association with the true king described on a preceding page. Several other similar specimens seen. These forms are derived from nymphs of the second form, *i.e.*, in the stage preceding the acquisition of the long wing-buds characterising nymphs of the first form, *i.e.*, those which are destined to develop into winged imagines. In second form nymphs, and neoteinic queens developed from them, the mesonotum and metanotum, including wing-buds, measure 2.35 in length; in nymphs of the first form, *i.e.*, potential winged imagines and true kings and queens, the length is 4.25. The antenna in each is 17-jointed.

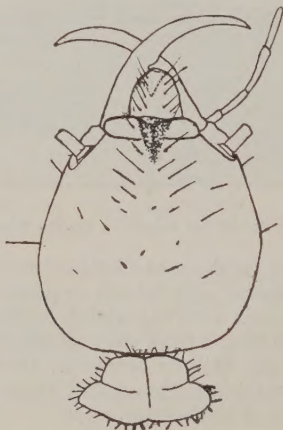


Fig. 4. *Drepanotermes silvestrii*, sp. n., head of soldier.

Soldier.—Head orange-rufous to Sandford's brown; mandibles mahogany-red; labrum yellowish, apex hyaline; antennae nearly as dark as head; junction of segments hyaline; pro-, meso- and metathorax russet to argus brown; legs and abdominal tergites light clay-colour.

Head (fig. 4) very large and broad, rounded behind, with a pale median suture from posterior margin forwards, widest behind the middle, sloping in towards the antennae, bearing a few moderately long reddish hairs, variable in size. Mandibles very long, falciform, each with a large angular tooth before the middle (fig. 5). Labrum large, wide at the base, sloping on the sides to the bluntly pointed apex. Clypeus three times as wide as long, divided into two lobes by a deep and wide median cleft, which extends posteriorly into the front of the head. Antennae 17- or 18-jointed, generally segmented as in *D. rubriceps*, Frogg., sometimes third and fourth joints closely fused and together only equal to sixth in length.

Prothorax (fig. 4) much narrower than head, anterior half rounded and bent up in front, slightly emarginate in middle, postero-lateral angles rounded, hind margin rounded and slightly emarginate in middle; the margin clothed with short stout reddish hairs. Mesothorax narrower and shorter than prothorax, hind margin with a few stout reddish hairs. Metathorax as wide as prothorax and clothed like mesothorax. Legs very long and slender, with scattered reddish hairs, fourth tarsal very long. Tibial spurs 3 : 2 : 2, as in other *Drepanotermes* and *Hamitermes*.

Abdomen elongate, narrow, with scattered stout reddish hairs and a few slender golden ones on tergites and sternites. Cerci long and slender. Styli present or absent.

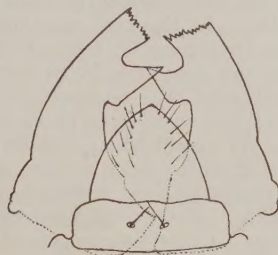


Fig. 5. *Drepanotermes silvestrii*, sp. n.,
base of jaws, labrum and clypeus of
soldier.

Measurements: Total length, 6.25-7; head and mandibles, 2.75-3.1 long; thorax and abdomen, 4.4-5 long; mandibles, 1.31-1.64 long; head, 1.6 wide; 1.25-1.35 deep; antennae, 3.29-3.61; prothorax, 0.51-0.56 long, 1.03-1.12 wide; tibia (i) 1.5, (ii) 1.5, (iii) 2.11-2.39; abdomen, 1.5 wide.

Worker.—Colour of head as in soldier, or a little darker, with pale median suture extending forwards from the posterior margin, widening behind the fontanelle and spreading out behind the frons; clypeus clay-colour, labrum yellow-ochre; antennae a little paler; rest of insect clay-colour; prothorax a little darker than tergites and legs. Immature workers and soldiers have body and legs tinged with rose pink.

Head large, rounded on the sides and behind, nearly as wide as long; widest behind the base of the mandibles. Labrum large, convex, swollen on the sides, rounded in front. Anteclypeus membranous, short, pointed. Postclypeus large, convex at base, not quite as long as wide, sides rounded, anterior margin truncate. Antennae very long, 18-jointed, arising within a deep cleft situated well in from sides of head. Fontanelle as in imago.

Prothorax as in soldier, more setose, much narrower than head. Legs long and slender, clothed with scattered reddish hairs. Tibial spurs 3 : 2 : 2.

Abdomen elongate oval, hairs more numerous and more slender than in soldier. Cerci long and slender.

Measurements: Total length, 7-7.5; head, with mandibles, 2.16-2.35 long; thorax and abdomen, 5.5 long; head, 1.93 wide; antennae, 3.61; prothorax, 0.56-0.6 long, 1.22 wide; mandibles, left, 0.97 long, 0.65 wide, right, 0.86 long, 0.77 wide.

Biology.

This is one of the three predominant species of mound-building termites that are found in the Townsville district, N. Queensland. It inhabits the same localities as *H. perplexus*, sp. n., and the termitaria of the two species are often found in close proximity, although those of the latter are rather more common, especially on hill-sides. On the higher and stony localities many large colonies live entirely in underground galleries, the extent and nature of which have not yet been investigated sufficiently to determine whether they are connected with large masses of cells and passages comparable with termitaria. This seems most probable, since it is known that these colonies collect and store considerable quantities of food, and that eggs, young larvae and the reproductive forms are not found in the galleries near the surface, which serve apparently only for the accommodation of workers and soldiers, and a few adolescents of these castes, and for the temporary storage of food material during and just after harvesting operations. As all the normal castes are reared by these colonies, it seems reasonable to assume that each is provided with an underground system suitable for the location of the royal pair and their young and for the storage of food. On the other hand, considerable excavating failed to disclose a regular nest or "nursery" in the closely allied species *D. septentrionalis*, sp. n., in the Northern Territory (Hill, 1915). In the case of *D. septentrionalis*, small foraging parties of soldiers and workers are commonly found in the termitaria of *Coptotermes* and *Eutermes*, but this is not the case with *D. silvestrii*. Access to the surface is gained by means of numerous small oval openings, from 18 in. to 3 ft. apart, and extending over an area of from 6 ft. to 12 ft. in diameter. These openings measure about 3 mm. long by 6 mm., and except when actually in use, *i.e.*, at harvesting or "swarming" periods, are sealed with earthy matter, either level with the surface or just below it, in either case rendering their detection very difficult. Similar surface openings are found in the vicinity of termitaria, when these are constructed; but they appear to be used solely at harvest time—certainly not to provide a means of exit for the winged forms at the time of swarming. The natural dispersal of the imagines has not been observed, and it is not known whether the phenomenon occurs during daylight or at night. A day or two before swarming takes place, slits are cut in the walls of the termitarium, generally in several places near the outer margin and several inches above ground level. These slits are sealed over by a projecting crust of moist earthy matter, as in *H. perplexus*, sp. n., and remain thus until weather conditions are favourable for the flight, after which they are cemented up flush with the general surface of the walls.

One of the most remarkable habits observed in this species, and also in *D. septentrionalis*, is that of gathering food supplies by day as well as by night. Froggatt (1915) observes that travellers in the bush, who have gathered a mass of dried grass upon which to make their temporary bed, have been aroused to find hordes of termites (species not stated) cutting the material into lengths and removing it for food. Such is by no means a rare experience in North Australia, and it occurs during the day as well as at night, *D. septentrionalis* being the species concerned in all cases which have come under my notice. In this district I have frequently seen countless thousands of soldiers and workers of *D. silvestrii* issuing from several holes in the surface and spreading out in irregular columns over an area of several yards, each worker cutting off a length of grass (leaf or stem), a piece of eucalyptus leaf or twig, or seizing a seed or small piece of bark and hurrying back along the column to one of the openings, at each of which there is a good deal of congestion, but no sign of disorder or wasted effort. Throughout these operations the soldiers are much in evidence, regulating the traffic, scouting on the outskirts of the working parties, attacking marauding ants or any other insects or spiders they may encounter, and generally taking a strenuous and important part in the proceedings. Their behaviour is in marked contrast to that of their near allies the *Hamitermes*, and

many other species, in which the soldiers appear to be the embodiment of cowardice and uselessness. On one occasion harvesting operations were observed at night on the roadside in one of the more populous residential areas of the town, the material gathered being almost entirely coarse dry grass, which was cut into pieces about half an inch in length. The nature of the food varies according to the season of the year, the flora in the immediate vicinity and other circumstances. When there is a plentiful supply of dry grass this material appears to be most favoured, but there is nearly always present a quantity of grass and other seeds and a good deal of vegetable debris. In the vicinity of eucalyptus trees they gather pieces of leaf, leaf-stems, twigs and bark. The latter are carried into the termitaria in the rough state and afterwards dressed into pellets of varying size and shape. None of the species of this genus are wood-eaters, nor are they known to attack cultivated cereals.

The termitaria are nearly always low, flat and more or less circular masses composed of intensely hard cement-like material, varying in toughness according to the soil in which they are situated. In size they vary from about 8 in. to 2 ft. in height by 2 ft. 6 in. to 8 or 9 ft. in diameter. In gross appearance they resemble a mass of soft mud which has spread over the surface and hardened by evaporation (Pl. ix, fig. 1). There is no well-defined outer casing or wall (Pl. ix, fig. 2) as in nests of *Coptotermes*, the whole of the superstructure being composed of similar material. The interior is occupied by very large flattened chambers connected with each other by small circular holes large enough to permit of the free passage of soldiers and workers from chamber to chamber. Similar but rather larger chambers extend below ground, under the middle of the superstructure, to a depth roughly corresponding to the height of the latter. These chambers are excavated in the soil, and are much less resistant to digging operations than those above ground. Below them are several passages extending more or less vertically into the soil beneath. The majority of the chambers in the superstructure are occupied by workers, soldiers, and older adolescents, and by masses of grass and other foodstuffs. The latter is generally stored in the rather smaller outer cells, many groups of which are reserved for the reception of the waste matter from the community, *i.e.*, alimentary rejectamenta and the heads of dead soldiers. Evidently much of the waste material is carried in the jaws to these chambers, where it is tightly packed until the space is entirely filled, then the small entrances are cemented up, apparently never to be reopened. Other chambers are reserved for the reception of the faecal matter of certain individuals, probably soldiers and workers, who evacuate directly into them. Such chambers, when in use, are indicated by a deposit of more or less liquid matter just within the small entrance hole, the remainder being empty. As the deposit increases and hardens the entrance becomes blocked and is then cemented up. Analyses of the rejectamenta in these termitaria show that they contain about 32 per cent. of inorganic matter. Additions to these nests are nearly always made by extending the outer walls without increasing the height, and the increase in the diameter of the superstructure is greatly in advance of that of the underground portion. The latter is occupied by the reproductive forms, eggs, larvae and nymphs, and by their attendant soldiers and workers.

All the different castes have been found in the same nest and at the same time, but an ovigerous neotenic queen has not been found in a nest presided over by a true queen. The soldiers are very numerous, active and pugnacious, and are capable of a most effective fight against marauding ants. When the termitarium is broken into the soldiers rush out in all directions, attacking every animate object they come in contact with—their fellow-soldiers and workers, ants, lizards and one's hands receiving equal attention. Some few devote their energies to rescuing their defenceless larvae, but this function devolves more upon the workers, who are hardly less pugnacious. Normally the colony is presided over by one true queen, who is generally located at, or just below, ground-level in a flattened cell of rather smaller size than the average cell in these nests. In one case only has a true king been found in the

queen cell. The true queen produces an enormous number of eggs, which are carried away by the workers and stored in masses in cells near the walls or near the queen-cell. Egg-laying is not confined to one particular season of the year, but it is not a continuous process, since eggs are often absent in certain thriving colonies while present in great numbers in others close by. Neoteinic queens are substituted for a true queen when a colony is naturally or designedly orphaned. In one colony a true king was found in a large cell with one ovigerous neoteinic queen; in another there were one true king and two of these neoteinics, in a third there were two neoteinics only, and in a fourth one neoteinic king and two neoteinic queens. Neoteinic queens of this species produce neoteinic males and females, as well as soldiers, workers, and nymphs of the first and second form.

The following field notes refer to termitaria of this species which have been kept under observation for some time:—

(1) This colony was orphaned on 22nd August 1919. When examined on 15th June 1920, it contained 20 young neoteinics of both sexes. There were no eggs or very young larvae present, but there were numerous half-grown larvae and second form nymphs. On 26th October 1920, two ovigerous neoteinic queens and four neoteinic males were removed from the nest. Eggs, young larvae and nymphs of the second form were plentiful. Some of the latter and one young neoteinic female were left in the nest, with workers and soldiers. By 15th February 1921, the termitarium was again restored to its original size and presented a very prosperous appearance. Eggs and young larvae were present, but no gravid female could be found. There were no young neoteinics present, but the second form nymphs which were left in the nest on the 26th October had now developed into nymphs of the first form. The parent of the eggs and young larvae found on this date was presumed to be the young neoteinic female left in the nest on 26th October.

(2) This nest was orphaned on 15th June 1920. On 26th October 1920, it contained four ovigerous neoteinics and nine immature neoteinic males and females. There were present also numerous second form nymphs, besides the usual workers and soldiers. The termitarium was now completely destroyed. On 15th February 1921, the nest was found to have been rebuilt to its original size and to contain numerous eggs, young larvae and nymphs of the second form. There were no nymphs of the first form or imagines present and the parent of the eggs and young larvae was not found. The whole termitarium was again destroyed, and on 18th March 1921 a good deal of it was found to have been rebuilt.

Each of several other nests which were orphaned at different periods of the year were found to contain neoteinic queens when examined subsequently. It has not been ascertained if a colony once deprived of its true queen is ever again presided over by another true queen; the contrary appears to be the case. In nests which are presided over by a true queen, or by one or more gravid neoteinics with numerous neoteinics in reserve, nymphs of the second form are found throughout the year, excepting from the middle of December to the end of January. A moult takes place about the former period, and the resulting first form nymphs have been found as late as 13th February, but the majority undergo their final moult and appear as imagines about the beginning of January, and all have moulted before the 8th March. When true queens or mature neoteinic queens are not present, nymphs of the second form may be present throughout the year. First form nymphs have not been found later than 15th February or earlier than 5th November. The actual date of swarming is determined by rainfall. In 1919–1920 first form nymphs were plentiful in the nests on 5th November 1919; the final moult took place between this date and 8th December, when most of the imagines were capable of flight, although some had not yet moulted. On 6th January and 15th January (1920) first form nymphs and imagines were still present in the nests. The former moulted before 30th January, and swarming took place before 10th February. In 1921 the wings of the majority

were fully developed on 15th February, but on 8th March, up to which date only light rain fell, these forms were still present in all the nests examined. On this date the tips of the wings showed marked damage due to prolonged occupancy of the parent nest. Similar conditions prevailed in the nests of *Hamitermes perplexus*, sp. n. Heavy showers fell on the night of the 9th March and throughout the day and night of 10th. Swarming of *H. perplexus* took place during the afternoon and evening of the latter date. The swarming of *D. silvestrii* was not observed, but probably took place about the same time, since none of the nests contained imagines on 14th March.

It is not intended to discuss in detail here the numerous other forms of life which have been found in termitaria, but brief mention may be made of one species which plays an important part in the economy of two species of termites dealt with in this paper. At a very rough estimate it may be said that 80 per cent. of the termitaria of *D. silvestrii* and *H. perplexus* are invaded and permanently occupied by the very common and widely distributed ant, *Iridomyrmex sanguineus*, Forel, which is particularly abundant on the low-lying country in the vicinity of Townsville. The termitaria are entered by means of holes burrowed into the walls (Pl. xii, fig. 2), in and out of which pass endless streams of ants in their journeys from one nest to another. If a termitarium is cut open vertically, it will be found that the ants have greatly enlarged the original galleries so as to form large flattened chambers in tier upon tier, until finally the greater part of the structure is in their undisputed possession. The floor of each cell is thickly covered with the eggs, larvae and pupae of the invaders, and immense numbers of ants throng all parts not actually in possession of the termites. As the ants extend their sphere, the termites are driven back from chamber to chamber and destroyed, until but a few stragglers are left. The complete, or nearly complete, occupation of a termitarium is evidently a matter of time, during which the advance is being constantly delayed by the termites walling up their galleries and passages as they retreat. The remains of the dead termites in the chambers occupied by ants show clearly that the nests are not attacked merely to provide a dry and safe shelter, but that the original occupants are used as food. Immediately the walls are broken with the pick the ants swarm out in countless thousands, destroying and carrying off the dislodged termites, crawling up one's legs and attacking one's hands, head or any skin surface to which they can gain access. Others of their kind gather from all directions to take part in the onslaught, until the nest and the surrounding ground is a seething mass of insect life. Under these conditions a close examination of the nest or its occupants is impossible, and it is only by finding an ant-free nest that one can hope to investigate its interior. Within a few minutes of the nest being broken into all the neighbouring ant-infested termitaria of these two species will be found to contain the bodies of freshly killed termites, while files of ants pass to and fro so long as a termite remains exposed to attack. Plate xii, fig. 1, shows ant tracks made on the surface of the ground approaching a mound of *H. perplexus*. It is a remarkable fact that the mounds of a certain species of *Eutermes*, which are very common amongst those of the *Drepanotermes* and *Hamitermes*, are never molested by *Iridomyrmex*.

The imagines of the beetle, *Cryptodus grossipes*, Fairm., have been found in the cells of *D. silvestrii*, and *Mandalotus germinatus*, Lea, has been taken on two occasions in the nests of *H. perplexus*. Their relationship to their hosts is not known. *Bubaris indemnis*, Pascoe, has been found under the walls of termitaria of several kinds, but they appear not to come directly into contact with the termites.

Ciliates (? *Trichonympha*), which occur in vast numbers in all the workers and soldiers and in many imagines of *Mastotermes darwiniensis*, Frogg., in Townsville, have not been found in *Drepanotermes silvestrii*, or in any other local species of termite.

***Drepanotermes septentrionalis*, sp. n.**

Termes rubriceps, Hill (*nec* Frogg.), Proc. Linn. Soc. N.S.W., xl, pt. 1, 1915.

Imago.—Head bay, clypeus argus brown; labrum, palpi, antennae and legs buckthorn brown, anteclypeus lighter; thorax and abdominal tergites auburn; lower surface of abdomen uniform ochraceous tawny; wings Brussels brown, faintly tinged with yellow behind second vein.

Head wide, rounded behind and on the sides, flat on the summit, moderately hairy. Labrum moderately large, swollen on the sides, rounded in front. Anteclypeus yellow, membranous, slightly pointed in front. Postclypeus convex, twice as wide as long, with median suture very distinct. Eyes small, circular (0·376 diameter), prominent. Ocelli broadly oval, widely separated from eyes. The small deep impression between ocelli and clypeus pale-coloured. Fontanelle broadly oval, about the size and shape of ocelli, with short indistinct forward extension, similar to that of *D. silvestrii*, sp. n., but slightly larger. Antennae 18-jointed; 1st segment moderately long and wide; 2nd half as long as 1st; 3rd, 4th and 5th small and closely fused; 3rd and 4th equal to each other, and a little longer than 5th; 6th longer and wider than 5th.

Thorax similar to that of *D. silvestrii*, but more rounded on the sides, similarly clothed. Legs as in *D. silvestrii*.



Fig. 6. *Drepanotermes septentrionalis*, sp. n., wings of imago.

Wings (fig. 6) with the margin ciliate; membrane with many hairs, subcosta very short, hardly extending beyond suture, costa and radius well separated, the latter very dark and connected with the former near the apex of the wing by a few indistinct nervures; median of the fore-wing branching from the radius within the wing-stump, that of the hind-wing just beyond suture, nearer to cubitus than to radius; branches of the median and cubitus very irregular and not alike in either fore- or hind-wing.

Abdomen elongate, nearly cylindrical, moderately densely clothed with short reddish hairs; ten dorsal and six ventral plates distinctly visible. Cerci as in *D. silvestrii*.

Measurements: Length with wings, 15; length without wings, 8; head, with mandibles, 2·06 long; head, at and including eyes, 1·78 wide; prothorax, 1·03 long, 1·22 wide; fore-wings, 13 long, 3·25 wide; hind-wings, 12·5 long, 3·5 wide; abdomen, 1·73–1·92 wide.

Soldier.—Very like *D. silvestrii*, sp. n., from which it differs in having the labrum larger and more rounded at the apex, clypeus shorter and less strongly lobed, antennae (fig. 7) of the same number of joints, *i.e.*, 17 or 18, but the size and shape of the basal joints very distinctly different, *viz.*, in *D. septentrionalis* the 1st joint is shorter and wider, the 2nd shorter and narrower, the 3rd and 4th very short, together equal

to the 3rd in *D. silvestrii*, 5th about half the length of corresponding joint in the latter species. The head very slightly redder than in the allied species. In size it is intermediate between individuals of *D. silvestrii* from high stony localities (Castle Hill, Townsville), and those from the low-lying country in the vicinity (Townsville Common).



Fig. 7. *Drepanotermes septentrionalis*, sp. n.,
basal joints of antenna of soldier.

Worker.—Very like that of *D. silvestrii*; head more reddish, median suture very obscure, not widening in front to surround the fontanelle; fontanelle hardly visible; antennae with 18 joints, stouter, but otherwise similar.

This caste, like the soldier, is intermediate in size between *D. silvestrii* from the hill-sides and from the plains, as shown by a series of measurements of antennae, mandibles and tibiae.

Biology.

The imago was originally described under the name of *Termes rubriceps*, Frogg., from a de-alated female taken on 11th January 1914 (Hill, 1915), and is here re-described from a perfect specimen of the same sex taken under similar circumstances and in the same locality on 3rd February 1918.

From a very thorough knowledge of all the country on either side of the Darwin-Katherine Railway within 60 miles of the coast, I am convinced that these termites do not construct termitaria, but live in rambling underground galleries as previously described (Hill, 1915).

Drepanotermes daliensis, sp. n.

Soldier.—Head very dark, nearly black; front of head, clypeus, anterior part of prothorax and mandibles a little lighter, clypeus yellow; antennae, palpi and legs ochraceous tawny.

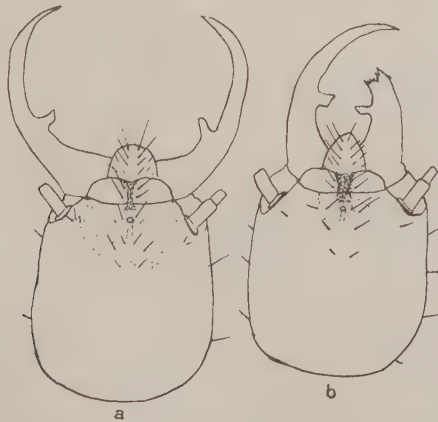


Fig. 8. Head of soldier of (a) *Drepanotermes daliensis*, sp. n.; (b) *D. perniger*, Frogg.

Head (fig. 8,a) very large, widest behind, sloping in slightly to the base of the jaws; frons flattened, a little rugose, median suture indistinct. Mandibles very long and slender, falciform, each with a large angular tooth nearer to the base than to the apex

and generally directed slightly forward. Labrum large, convex, rounded on the sides to the bluntly rounded apex. Clypeus large, slightly convex, emarginate in front, divided medially by a deep depression. Fontanelle very indistinct. Antennae (fig. 9, *b*) very long and slender, 19- or 20-jointed, rarely 18; 1st joint twice as long and about half as wide as 2nd; 2nd nearly cylindrical, one-third longer than 3rd; 3rd narrowest at base, wider than 4th at apex; 4th shortest of all; 5th a little longer and wider than 4th; 6th nearly as long as 2nd; 7th longer and narrower than 6th.

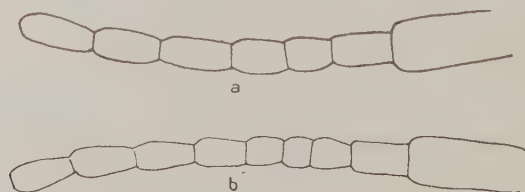


Fig. 9. Proximal segments of antenna of soldier of
(*a*) *Drepanotermes perniger*, Frogg.; (*b*) *D. daliensis*,
sp. n.

Prothorax similar to that of *D. silvestrii*, but anterior half narrower. Legs long and slender, with scattered hairs except on inner side of tibiae, which are fringed with longer and stouter hairs; mid-tibiae with two short stout apical setae on upper side, which are absent in hind tibiae; first three tarsals very short, 4th very long; tibial spurs 3:2:2.

Abdomen as in *D. silvestrii*, sp. n.

Measurements:—

		<i>D. daliensis</i> , sp. n.	<i>D. perniger</i> , Frogg.
Head and mandibles, long	..	3.290–3.807	.. 3.196
Thorax and abdomen, long	..	3.290	.. 3.290
Mandibles, long	..	1.551	.. 1.598
Head, deep	..	1.175	.. 1.034
„ wide	..	1.645	.. 1.598
Antennae	..	3.666	.. 3.666
Prothorax, long	..	0.658	.. 0.564
„ wide	..	1.128	.. 1.081
Tibia (i)	..	1.410	.. 1.457
„ (ii)	..	1.457	.. 1.363
„ (iii)	..	2.115	.. 2.303
Abdomen	..	1.05	.. —

Worker.—Colour of head as in soldier; clypeus and jaws (excepting teeth) tawny olive; labrum, palpi, antennae, thorax and legs clay-colour.

Head large, rounded behind and on the sides, widest near the middle, a pale coloured and very distinct median suture extending from back of head forwards, spreading out around the fontanelle, which is a sharply defined, small, broadly oval depression; frons sloping slightly to the base of the clypeus, very faintly rugose. Labrum large, very convex, covering apex of jaws, narrower than anteclypeus at base, swelling out sharply in the middle to the rounded apex. Anteclypeus large, middle of anterior margin produced into a point. Postclypeus large, twice as wide as long, convex, truncate in front, strongly arcuate behind, median suture hardly visible, with very few hairs. Antennae 19- or 20-jointed; 3rd, 4th and 5th joints short; 4th shortest.

Prothorax as in soldier, entire surface with stout reddish hairs. Legs long and slender, as in *D. silvestrii*, sp. n.

Abdomen narrow, tapered to the pointed apex, with pale reddish hairs of various lengths. Cerci long and slender.

Measurements :—

			<i>D. daliensis</i> , sp. n.		<i>D. perniger</i> , Frogg.
Total length	..	..	6		
Head, long	..	..	2.115–2.250	..	1.927
Thorax and abdomen, long			3.995	..	3.525
Head, wide	..	..	1.739	..	1.692
Antennae	..	..	3.700	..	3.800
Mandibles :					
left	..	..	.987 long by .658 wide	..	.890 long by .640 wide
right	..	..	.893 long by .752 wide	..	.799 long by .750 wide
Prothorax, long	..	..	0.705	..	0.611
" wide	..	..	1.034	..	1.128
Tibia (i)	..	..	1.316	..	1.363
" (ii)	..	..	1.222	..	1.316
" (iii)	..	..	1.924	..	2.068

This species is very closely related to *D. perniger*, Frogg. The soldiers are distinguished as follows : In *D. daliensis* the head is very much darker ; the frons is slightly protuberant and rugose, the middle falling gently into the frontal opening. In *D. perniger* (fig. 8, *b*) the frons is only slightly protuberant, but more rugose. The clypeus in *D. daliensis* is less lobed in front and the furrow dividing it medially is narrower and shallower ; the labrum is much shorter and rounder ; the antenna has always one, but generally two or three, additional joints, the fourth and fifth of which are very much shorter than in *D. perniger* (fig. 9, *a*). The worker may be distinguished from that of *D. perniger* by its darker head and 19- or 20-jointed antennae.

Type series in South Australian Museum, co-types in author's collection.

NORTHERN TERRITORY : Upper Daly River (*H. Wesselman*).

Drepanotermes perniger, Frogg.

In his discussion of this species Dr. Mjöberg (1920, p. 69) remarks that the soldiers from different localities show considerable differences in the colour, size and shape of the head, but that he has found no constant characters which justify him in regarding the pale-headed forms from North Queensland and Kimberley as specifically distinct from the typical dark-headed forms. Then follows a description of the imago, but unfortunately no locality is given, nor is it stated if his specimens were associated with pale- or with dark-headed soldiers. On page 57 the same author gives a key for the differentiation of the soldiers of the two hitherto described species of *Drepanotermes*, viz., *D. perniger*, Frogg., and *D. rubriceps*, Frogg., the former being distinguished by the very long jaws and very broad, projecting tooth, and the latter by shorter jaws and triangular tooth. The jaws of *D. perniger* are figured on page 76.

In this paper I have referred to the similarity which exists in the heads of soldiers of certain species the imagines of which show marked specific differences ; for this reason I cannot agree with the suggestion that pale- and dark-headed forms are referable to a single species. If the imagines described by Dr. Mjöberg as *D. perniger* were associated with pale-headed soldiers it is most probable that they are referable to another species. With regard to characters given for the soldiers of *D. perniger* and *D. rubriceps*, it may be said that the shape of the mandibular tooth is variable in specimens from the same colony, and that the form figured by Dr. Mjöberg for *D. perniger* is one commonly found in *D. rubriceps*, *D. silvestrii*, *D. septentrionalis* and occasionally in *D. daliensis*.

Specimens of soldiers and workers in the South Australian Museum from Beverley, W. A., Moorella, C.A., and Leigh Creek, C.A., agree perfectly with co-types of *D. perniger*, Frogg., and are undoubtedly referable to that species. I have not had an opportunity of examining specimens of *Drepanotermes* from Kimberley, nor dark-headed forms of the genus from Queensland.

***Drepanotermes rubriceps*, Frogg.**

Termes rubriceps, Froggatt, Proc. Linn. Soc., N.S.W, xxii, 1897, p. 730.

In an earlier paper (Hill, 1915) I described a de-alated imago under the above name, the determination of the species having been made for me by Mr. Froggatt, from soldiers and workers only. Later, a perfect specimen was secured from the same locality (Darwin, Northern Territory) and under similar conditions. Recently I have had for examination a series of imagines, soldiers and workers from Tennant's Creek and Leigh Creek, Central Australia (South Australian Museum Collection), which, although not compared with the type soldiers and workers, I consider to be *D. rubriceps*, Frogg., the type locality of which is McKinley Ranges, Central Australia. A comparison of the winged forms from Darwin with those from Central Australia shows that they are referable to two quite distinct species. The structural differences between the respective soldiers, however, are hardly appreciable. The heads of the Central Australian specimens are distinctly lighter than those of the Northern species and there are small differences in the structure of the antennae.



Fig. 10. *Drepanotermes rubriceps*, Frogg., head of imago.

The following is a description of the imago of this species. The Northern species is described in the preceding pages under *D. septentrionalis*.

Imago.—Head very dark brown; clypeus yellow-ochre; antennae darker than clypeus, brownish; trophi and ventral surface antimony yellow; prothorax yellow-ochre, with brown blotches; wing-stumps and abdominal tergites argus brown, the former with dark vein bases; wings brown, radius and branches of the cubitus very dark, costal margin pale.

Head (fig. 10) large, rounded behind, flat on the summit, clothed with numerous short, fine, pale hairs. Labrum narrow at base, swollen on the sides, rounded in front. Anteclypeus membranous, pointed in front. Postclypeus moderately large, twice as wide as long, convex, rounded behind, truncate in front, sloping on the sides. Fontanelle very small, lanceolate, with anterior end bifurcated. Eyes large, projecting moderately, nearly circular (0.610×0.470). Ocelli large, oval, oblique, a little less in length than short diameter (horizontal) of eyes, very close to the eyes, their anterior margin a little posterior to the anterior margin of eyes. Mandibles with dentition as in *D. silvestrii*, sp. n. Antennae very long and slender, 16-jointed;

1st joint more than twice as long as 2nd; 3rd about as long as 2nd, narrower and more turbinate; 4th a little shorter than 3rd, wider, oval, always shortest of all, but rarely markedly so; 5th longer and wider than 4th; 6th a little shorter and narrower than 5th; 7th to 9th, inclusive, increasing gradually in length; 10th to 14th about equal to each other, very little longer than 9th; 15th and 16th slightly longer than 14th, equal to each other; joints 5 to 16, inclusive, more or less stalked; 5 to 15 slightly turbinate; 7 to 16 distinctly slender; number and shape of joints apparently very constant.

Prothorax roughly triangular, setose, nearly flat, wider than long, anterior margin slightly arcuate, bent up in the middle, antero-lateral angles rounded, sides nearly straight, sloping sharply to the rounded posterior margin, hairy. Mesothorax with a broad dark stripe down the middle; wing-stumps large, setose, about two-thirds as long as the mesonotum. Metanotum similar, but wing-stumps small, half as long as the visible portion of the metanotum. Legs as in *D. silvestrii* (fig. 2).

Wings (fig. 11) very large and broad; fore-wing a little longer and a little narrower than hind-wing, margin ciliate. Anterior margin distinctly yellow-ochre. Costa and radius dark at base, becoming yellowish further on, the latter well separated



Fig. 11. *Drepanotermes rubriceps*, Frogg., wings of imago.

from the former in the proximal half of the wing, closer but distinctly separated in the apical half to near its junction just before the apex. Median dark at the base only, the rest very indistinct, running much nearer to the cubitus than to the radius. In the fore-wing the median separates from the radius within the wing-stump, runs straight to the apex of the wing, giving off five or six ill-defined superior branches. In the hind-wing the separation from the radius takes place beyond the suture, there are seven or eight very obscure branches, those near the base being short, the others running out to the wing margin, which they join just above or below the apex. The cubitus of the fore-wing joins the hind-margin a little below the apex and gives off from 12 to 15 branches, the first 9 to 12 of which are very distinct and some are forked. In the hind-wing there are generally 12 branches, simple or forked once or twice. Other variations are common.

Abdomen large, showing nine distinct tergites, each clothed with fine, short, pale hairs and a fringe of large golden hairs on posterior margin. Sternites with indistinct brownish patches laterally. Cerci very short and broad.

Measurements: Length with wings, 21-22; length without wings, 11; head, with mandibles, 2.35 long; head, at and including eyes, 1.88 wide; antennae, 3.29-3.75; mandibles, right 0.94 long, 0.75 wide; left, 0.94 long, 0.6 wide; prothorax, 1 long, 1.78 wide; fore-wing, 18.3 long, 5 wide; hind-wing, 17.5 long, 5.25 wide; tibia (i) 1.36, (ii) 1.5, (iii) 2; abdomen, 3.5 wide.

Soldier.—Head (fig. 12) yellow-ochre to ochraceous orange; labrum whitish yellow; clypeus with anterior margin bordered with hyaline membrane; mandibles a little darker than head, darkest at tip; remainder of insect pale yellow.

Antennae very long and slender, 17- or 18-jointed; 1st joint long, rather more than twice as long as 2nd and one-third wider; 3rd as long as 2nd, but narrower; 4th shorter than 3rd but equally wide, more or less fused with it; 5th as long as 3rd, narrow; 5th to 9th increasing successively, all elongate, narrow; 10th to 18th about equal in length, a little shorter than 1st.

Measurements: Head and mandibles (crossed), 2.82 long; head, 1.73 wide; antennae, 3.57; thorax and abdomen, 3.29 long; prothorax, 0.6 long, 1.13 wide; tibia (i) 1.27, (ii) 1.45, (iii) 2.06.

The imago differs from *D. silvestrii* in having a larger body, wings longer and paler, lower surface of abdomen paler, much smaller and differently shaped fontanelle, larger eyes, fewer joints in antennae (16 as against 18 in *D. silvestrii*), segmentation distinctly different, head and prothorax much lighter coloured. The soldier is lighter in colour than that of *D. silvestrii*, and the front of the head a little less rugose; otherwise there is little to distinguish them.

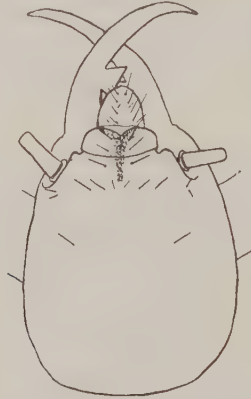


Fig. 12. *Drepanotermes rubriceps*, Frogg.,
head of soldier.

From *D. septentrionalis*, sp. n., the imago is easily separated by its larger size, longer and darker wings, darker prothorax, and two less joints in the antennae. From *D. perniger*, Frogg., as described by Mjöberg, it differs in being much larger, having much longer wings, and also in the eyes, fontanelle, and antennae.

Type series of imagines in South Australian Museum; co-types in author's collection.

CENTRAL AUSTRALIA: Tennant's Creek (*J. F. Field*); Leigh Creek, Everard Ranges (*S. A. White*). WESTERN AUSTRALIA: Mullewa.

Hamitermes parvus, sp. n.

Imago.—Clypeus, meso- and metathorax, legs, abdominal sternites and tergites mummy-brown; prothorax much darker brown; mouth-parts clay-coloured; tarsi pale stramineous; claws pale ferruginous; wings brown.

Head (fig. 13) clothed with numerous short and moderately long hairs, longer than wide, rounded behind and on the sides to the base of the jaws (widest part), flat on the summit. Fontanelle in the form of two elongate straight clefts in the middle line. Eyes small, hardly projecting beyond sides of head. Ocelli oval and widely separated from the eyes. Antennae 14-jointed, arising from a raised tubercle within a deep and wide fossa in front of the eyes, the tubercle being about equidistant

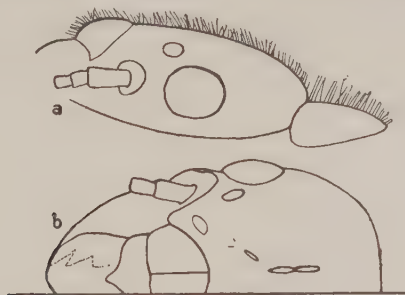


Fig. 13. *Hamitermes parvus*, sp. n., head of imago (a) in profile; (b) from above.

between the anterior margin of the eye and the postero-lateral margin of the clypeus; 1st joint twice as long as 2nd, 3rd shortest, indistinctly separated from the 2nd and 4th. Labrum rather narrow at the base, swollen on the sides, rounded in front. Anteclypeus arcuate anteriorly, slightly convex, half as long as wide, half as wide as postclypeus, divided medially by a suture which extends across the latter. Postclypeus large, convex, anterior margin slightly concave, posterior margin semi-circular, greatest length slightly more than greatest width.

Prothorax nearly twice as wide as long, very slightly convex and bent up along the anterior margin, antero-lateral angles rounded and slightly bent up, sides sloping sharply to the nearly straight posterior margin. Legs with fore tibiae and all femora stout; tibial spurs 3:2:2.

Wings (fig. 14) brown, large veins and first five or six branches of the cubitus well defined; entire margin excepting proximal fifth of hind margin ciliate; veins with a few long hairs along the entire length, venation variable and not always alike in either fore- or hind-wings of the same individual; cross suture straight.

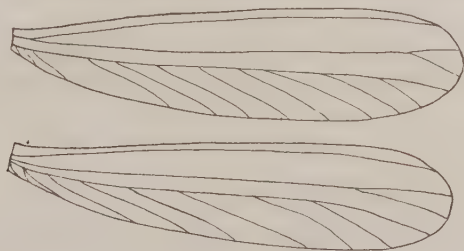


Fig. 14. *Hamitermes parvus*, sp. n., wings of imago.

Abdomen nearly cylindrical; seventh sternite of male much longer and darker than corresponding sternite of female, densely clothed with short fine reddish hairs. Cerci short, conical; basal segment very broad (0.8) and flattened.

Measurements: Length with wings, 6.25-7; length without wings, 3.25-4; head, with mandibles, 0.75-0.84 long; thorax and abdomen, 2.63 long; head, at

and including eyes, 0.65–0.67 wide; antennae, 1.08; mandibles, right, 0.41 long, 0.28 wide, left, 0.4 long, 0.25 wide; prothorax, 0.28 long, 0.51 wide; wings, 5 long, 1.27–1.4 wide; tibia (i) 0.51, (ii) 0.48, (iii) 0.7.

Soldier.—Head buff yellow; antennae, palpi, thorax and legs paler; abdomen grey (due to stomach contents); jaws castaneous, with basal half much paler.

Head (fig. 15) rounded behind and on the sides, compressed dorso-ventrally, clothed with scattered short reddish hairs. Mandibles short and stout, with a blunt angular tooth on each about the middle. Labrum broad at the base, sloping in to the rounded apex. Clypeus broad and rather indistinct. Antennae arising from raised tubercles close to the base of the jaws, 13-jointed; 1st joint nearly twice as long as 2nd; 2nd and 4th equal; 3rd half the length of the 2nd and 4th; 5th and 8th three-fourths the length of the 4th; 9th–11th equal to the 2nd; 12th rather longer; 13th longest, twice as long as 2nd and 4th.

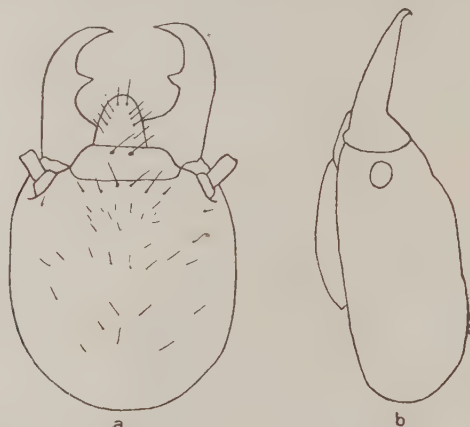


Fig. 15. *Hamitermes parvus*, sp. n., head of soldier
(a) from above; (b) in profile.

Prothorax similar to that of worker. Legs short and moderately stout; tibial spurs 3:2:2.

Abdomen elongate-oval, clothed with numerous moderately long and a few very long reddish hairs.

Measurements: Total length about 3.3; head and mandibles, 1.22 long; thorax and abdomen, 2 long; mandibles, 0.47 long; head, 0.65 wide, 0.47 deep; antennae, 0.86; prothorax, 0.18 long, 0.47 wide; tibia (i) 0.46, (ii) 0.37, (iii) 0.56; abdomen, 0.7 wide.

Worker.—Head creamy; mouth-parts, thorax and legs paler; abdomen nearly hyaline.

Head almost spherical, slightly longer than wide, clothed with scattered red hairs; labrum large convex, rounded in front; clypeus similar in shape to that of winged form, at each end a ferruginous spot (articulation of mandible). Antennae 13-jointed, segmented similarly to that of winged form, arising from a raised tubercle. Dentition as in imago.

Prothorax nearly twice as wide as long, arcuate and bent up in front. Legs stout; tibial spurs 3:2:2.

Abdomen elongate-oval, bluntly rounded at apex, clothed with moderately long and stout hairs, with a few much longer ones scattered over dorsal and ventral surfaces. Cerci large and prominent, base with several very long slender hairs.

Measurements : Total length (about), 3.47 ; head with jaws, 0.7 long ; thorax and abdomen, 2.68 long ; head, 0.64 wide, 0.32 deep ; antennae, 0.98 ; mandibles, left, 0.38 long, 0.25 wide, right, 0.36 long, 0.28 wide ; prothorax, 0.22 long, 0.4 wide ; tibia (i) 0.46, (ii) 0.38, (iii) 0.56.

The small size of the soldier of this species will at once separate it from any other described Australian *Hamitermes* ; its nearest ally is *Hamitermes latidens*, Mjöb., from which it may be distinguished, *inter alia*, by its smaller size and the form and number of joints in the antennae.

NORTH QUEENSLAND : Townsville.

Biology.

Winged adults, soldiers and workers were found in heavily manured garden soil on 10th December and 18th December 1919. About 50 points of rain fell on the night of 17th December, and at 8.30 a.m. on the following morning winged termites were noticed flying up from the very sandy soil. After some searching a small circular opening was found on a bare sandy space from which the winged forms were emerging. One soldier and several workers were congregating about the opening, apparently guarding the entrance to the nest while the winged forms made their exit. Between 8.30 a.m. and 9 a.m. on 16th and 17th November 1920, winged forms were again noticed rising from the grass-covered soil a few yards distant from where the first specimens were taken in the previous year. In most cases they fluttered feebly from a blade of grass or other object, flew a few yards and settled again in the grass, where most of them were caught almost at once by small ants (*Pheidole megacephala*). The first swarm (16th November) was preceded a few hours earlier by a heavy shower of rain and the second swarm, firstly, by a very copious watering of the adjacent soil from the pipe service and, secondly, by a heavy shower of rain about 5 a.m.

Hamitermes perplexus, sp. n.

Imago.—Head and prothorax dark brown (bay) ; postclypeus lighter than head, anteclypeus whitish with yellow blotches ; antennae and tergites of abdomen mummy brown ; on the first nine tergites a small clear mark on each side, distinctly comma-shaped on segments 3-6 inclusive ; sternites Dresden brown, first four paler than others and only very slightly darker at sides, the rest uniformly dark, plates 1-6, inclusive, with small clear mark at each end, 5-8 uniformly dark ; sternum and pleurae not darker than sternites of abdomen ; wings brown.



Fig. 16. *Hamitermes perplexus*, sp. n.,
head of imago.

Head (fig. 16) rounded behind, flat on summit, widest across the eyes, moderately hairy, hairs of variable length. Eyes large, projecting beyond sides of head. Ocelli oblique, oval, widely separated from the eyes. Fontanelle large, oval, with linear (5296)

forward prolongation, two oblique impressions in front. Anteclypeus produced in front; postclypeus large, convex, rounded behind, truncate in front, with distinct median suture. Antennae 15-jointed; 1st twice as long as 2nd; 3rd very short, smallest of all; 4th and 5th nearly equal to each other, larger than 3rd; 6th larger than 5th; 7th-12th nearly equal; 13th and 14th very little longer and more cylindrical than 12th; 15th longest, tapered from before the middle to the pointed tip. Very rarely the 5th and 6th joints on one side only are fused.

Prothorax slightly bent up in front, antero-lateral margin slightly rounded, sides narrowed to the emarginate posterior border, divided medially by a suture, which is very distinct in the anterior half; two clear impressions on each side behind the anterior margin; the whole surface moderately hairy. A distinct pale mark on each side of the median line of the metanotum.

Wings (fig. 17) with border ciliate excepting on proximal fifth of hind margin; venation very variable, often differing in both fore- and hind-wings of same insect; radius darker than costa, sometimes with short branches near apex of wing. In the fore-wing the median branches from the radius within the wing-stump, in the hind-wing the division is well beyond the suture; the median runs nearer to the cubitus than to the radius and gives off from three to eight branches to the anterior margin,



Fig. 17. *Hamitermes perplexus*, sp. n., wings of imago.

apex, or to the hind margin, the first branch generally arising about the distal third or fourth of the wing, but sometimes about the middle of proximal third. In some a short stout vein branches from the median at the proximal fifth and joins the radius about its proximal fourth; cubitus very irregular and seldom alike in the fore- or hind-wings of the same individual. In the fore-wing there are generally from six to eight simple branches, all of which often reach the posterior border before the middle; in the hind-wing there are from seven to eleven branches, some of which are forked. Associated with individuals having a wing venation as described above there are generally many with the venation described by Mjöberg (1920, p. 84) in *H. obtusidens*, Mjöb.

Legs ochraceous tawny, short; tibial spurs, 3:2:2.

Abdomen with ten distinct dark-coloured tergites; ventral surface much lighter. Styli wanting in both sexes.

Measurements: Length with wings, 12-13; length without wings, 7-8; head, with mandibles, 1.27 long; thorax and abdomen, 6.25 long; head, including eyes, 1.17 wide; mandibles, right, 0.72 long, 0.51 wide, left, 0.73 long, 0.41 wide; antennae, 1.7-1.8; prothorax, 0.61-0.65 long, 1-1.17 wide; tibia (i) 0.85-0.89, (ii) 0.84, (iii) 1.17; abdomen, 1.9 wide.

Neoteinic Queen.—Head and thorax ochraceous tawny to light orange-yellow; tergites of abdomen paler, rest of insect creamy.

Head about as long as wide, widest at the eyes, hairy. Eyes small, not projecting, pigmented in centre. Ocelli roundish, well separated from the eyes. Fontanelle a large globular protuberance. Anteclypeus half as long as postclypeus, nearly truncate in front, sometimes concealed; postclypeus convex, depressed in the middle line, hairy. Labrum swelling out on the sides, bluntly rounded in front, not covering apical teeth. Antennae 15-, rarely 16- or 17-jointed, very variable.

Prothorax as wide as head, shaped as in imago, clothed with red hairs. Wing-pads short, hind pair not reaching beyond middle of first tergite.

Measurements: Total length, 9.5-10; head, with mandibles, 1.32 long, 1.12 wide; abdomen, 2.8-3 wide.

Soldier.—Head ochraceous; mandibles pale ferruginous, a little paler at the base; antennae ochraceous with pale segmentations; clypeus and labrum stramineous with ochraceous blotches, remainder of insect stramineous.



Fig. 18. *Hamitermes perplexus*,
sp. n., head and prothorax of
soldier.

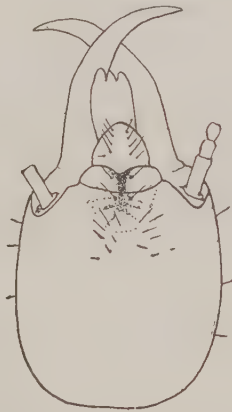


Fig. 19. *Hamitermes germanus*,
Hill, head of soldier.

Head (fig. 18) longer than wide, slightly curved on the sides, a bright ferruginous spot on either end of the clypeus. Labrum large, rounded on the sides, rounded in front, not reaching the mandibular teeth. Clypeus wider than long, convex, emarginate in front, divided in the median line by a deep cleft which extends into the head. Mandibles long and moderately slender, falciform, with a sharp backwardly directed tooth about the middle similar to that of *H. germanus*, Hill (fig. 19). Antennae 15-jointed; 1st joint twice as long as 2nd; 3rd half as long as 2nd, smallest; 4th and 5th nearly equal in length; 6th and 7th longer than 5th.

Prothorax (fig. 18) saddle-shaped, rounded and bent up in front, antero-lateral margin rounded, posterior margin rounded, slightly emarginate in the middle. Legs rather short and stout; tibial spurs, 3:2:2.

Abdomen with scattered, rather short, and a few long yellow hairs. Cerci with base short and moderately broad, apex elongate, sides nearly straight to near the pointed tip.

Measurements: Total length, about 5; head and mandibles, 1.83–1.97 long; thorax and abdomen, 3.1–3.7 long; head, 1.08 wide, 0.84 deep; mandibles, 0.98 long; antennae, 1.69; thorax, 0.36 long, 0.7 wide; tibia (i) 0.84, (ii) 0.75, (iii) 1.08.

Worker.—Head creamy; thorax and legs paler; antennae whitish, tinged with yellow-ochre, distal third darkest; abdomen white (greyish black when alimentary tract contains ingested matter).

Head about as long as wide, clothed with reddish hairs, some moderately long. Labrum large, covering mandibles. Anteclypeus narrow, bluntly pointed in front; postclypeus convex, with reticulate pattern. Mandibles with dentition as in imago. Antennae 15-jointed; 1st joint large, nearly twice as long as and much wider than 2nd; 3rd very small, smallest; 4th and 5th about equal to each other; 6th larger than 5th, but much smaller than 7th and 8th.

Prothorax with anterior portion narrowed and bent up, emarginate in the middle, posterior margin almost semicircular, the whole clothed with reddish hairs of unequal length.

Abdomen elongate-oval, moderately hairy. Cerci small, basal part without hairs, apical part tapered and drawn to a fine point at tip.

Measurements: Total length, about 5.15; head, with jaws, 1.15 long; thorax and abdomen, 4; head, 1.5 wide; mandibles, right, 0.61 long, 0.51 wide, left, 0.66 long, 0.42 wide; antennae, 1.46; prothorax, 0.37 long, 0.8 wide; tibia (i) 0.76–0.78, (ii) 0.67–0.7, (iii) 0.99–1.

NORTH QUEENSLAND: Townsville.

This species appears to be closely related to *H. laurensis*, Mjöberg, from which it differs in the shape of the head and antennae of the soldier and in the antennae of the neoteinic queen. From *H. meridionalis*, Frogg. (fig. 20), it differs in the



Fig. 20. *Hamitermes meridionalis*, Frogg., head of soldier.

soldiers in the shape of the jaws, colour of the head, form of the antennae, shape of the clypeus and distance of the antennae from the head margin. The winged forms of *H. laurensis* and *H. meridionalis* are not known.

Biology.

This is one of the commonest, if not the commonest, species of termite found in the vicinity of Townsville; how much further it ranges is not known. Like all the species of this genus known to me it is not a wood-eater, but lives on vegetable debris, such as the leaves, stems and seeds of herbaceous plants, the two former being cut into fragments and the latter stored intact in the termitaria. Food is gathered throughout the year, as required, and is stored in the outer galleries. In times of drought or after grass fires there is a noticeable absence of food in these galleries, and at no time is the accumulation of food comparable with that which is found in the nests of the grass-eating species of *Eutermes*. Incipient colonies, and colonies which for some reason or other have no termitaria, do not appear to make any provision for the storage of food in their underground galleries.

In these notes the word termitaria is used to indicate earthy or woody nests constructed by termites upon the surface of the soil, upon stumps, logs, stones, or in the branches of trees; the latter—arboreal nests or termitaria—appear to be constructed only by certain species of *Eutermes*. The species under notice normally constructs earthy nests, but it appears that these are not commenced until the colony has matured a considerable number of individuals of the worker caste in underground galleries. In some cases winged adults also are reared in these galleries. In discussing the habits of *H. eucalypti*, sp. n., reference is made to the construction of tube-like vertical ducts, by means of which the winged adults leave their underground galleries at the time of the annual colonising flight or “swarming.” Similar ducts are also, though rarely, constructed by *H. perplexus* for the same purpose, when winged adults are reared in underground galleries. These tower-like ducts are commenced at the end of the dry season after the first showers and before the regular rain sets in; for example, in the summer of 1919 the first heavy shower (0.5) fell on 17th December, and construction commenced on the following day and continued until 22nd December, by which date about 80 ducts were scattered over an area of about 20 ft. square.

It is a common occurrence to find small colonies of soldiers and workers in rambling galleries in the soil, or at the base of abandoned, or partly abandoned, termitaria of *Eutermes* and *Drepanotermes*, and in one instance a de-alated imago of *Eutermes* sp. was found with such a community.

Typical termitaria, however, are very commonly found on hillsides, near the foot of hills (Pl. x, fig. 1), and on the open or scrub-covered plains (Pl. x, fig. 2) to the westward of the town, and occasionally in town gardens and streets. Quite frequently the greater part of the mound rests upon a large rock projecting a few inches to a foot or more above the surface. In such cases, however, one portion of the mound is invariably in direct contact with the soil, and is pierced by the main galleries communicating with the earth below. It may be stated here that such communication is absolutely essential to the existence of all termites, excepting members of the genus *Cryptotermes*, which in many, if not most, cases normally live entirely cut off from access to the soil. By far the greatest number of nests are to be found on the open grazing country and adjacent scrubby areas. In the former localities the nests attain their maximum size and number, and associated with them are almost as many nests of *Eutermes* sp. and *Drepanotermes silvestrii*, sp. n. Near the margin of the lowest lying part of this area the nests of these three species are so numerous as to present a most remarkable feature of the landscape.

In size and shape the nests vary a good deal; those on higher and well drained positions being usually smaller and more pointed than those on the plains (cf. Pl. x, figs. 1 and 2). In the ground-plan, nests on the higher situations are circular or oval, in the latter case the long axis being directed north and south. A nest measuring, say, about 12 by 14 in. at the base would be about 15–18 in. high, with sides sloping

to the pointed apex. On the plains the nests are often very much larger and frequently they have the long axis directed north and south or north-west by south-east, the sides sloping to the bluntly wedge-shaped top, which is rounded off at each end and never surmounted by numerous small points as in *H. meridionalis*, Frogg. (Plate xi). Sometimes the western side is more or less convex and the eastern side vertical or bent over, as in the latter species. The maximum size of such a termitarium is about 6 ft. long by 2 ft. wide at the ground and 4 ft. high. Conical nests are not uncommon.

Only in recently constructed nests, built by large colonies whose former nests have been dismantled, or smaller original nests of strong colonies, are the galleries and passages within the termitarium numerous and extensive. In the great majority of cases the structure is intensely hard and composed almost entirely of earthy particles cemented together. The occupied portions are practically confined to the top and sides, the internal galleries being gradually filled with rejectamenta until they assume the toughness and density of the earthy portions. Additions are made throughout the year, as in *H. meridionalis*, and not only after the rainy season has set in, as stated by Jack (1897). These additions are small and local and usually take the form of thin layers added to the sides (Pl. xii, fig. 2), the insects working from holes cut in the adjacent walls. The almost solid interior is pierced by a few larger passages which pass down into the soil and beneath the walls. Food is stored in the outer galleries and is generally mixed with the bodies of their dead. Near the top of the nest the dead occupy more space than does the vegetable food. They consist chiefly of nymphs of the winged forms in the stage when the wing rudiments first appear; but workers and soldiers are to be found also. In nearly all cases the legs have been amputated. This habit of storing away the dead was first recorded by Mjöberg (1920) in *H. laurensis*, Mjöb., *H. meridionalis*, Frogg., and *Eutermes tyriei*, Mjöb., in North Queensland, but has long been known to occur in *H. meridionalis* in the Northern Territory, and in an allied species in Central Australia.

Another type of termitarium is that in which there is a more or less solid foundation a foot or more in height, upon which rest several larger or smaller cone-shaped points (Pl. xii, fig. 1). In many instances these nests are obviously constructed on the sites of old nests; in others there is nothing to indicate that such is the case. An examination of the smaller nests, and especially those constructed on land free from rock, shows clearly that the base rests on the natural surface, which is penetrated only by a few passages. Such nests are easily pushed over intact, and if not removed or broken into fragments, form the base of new termitaria, which the insects soon construct in the characteristic cone-like form. Sometimes several of these cones are built up vertically upon the upper surface of the now recumbent old structure.

The termitarium invariably contains two sterile castes, namely, soldiers and workers. In all species of the genus *Hamitermes* (*sensu restricto*) the former caste is represented by very few mature individuals, probably never more than 5 per cent. of the total number of workers, and in this species probably less than $\frac{1}{2}$ per cent. When the nest is broken into there is a general retreat to the remaining galleries, neither caste making any attempt to defend themselves, their fellows, or their home. In all strong colonies there are present also great numbers of young forms in various stages of development. Reproductive forms, or forms which mature into them, are nearly always present. In the earlier stages preceding sexual maturity the latter are creamy white or white, soft-bodied insects, longer and more slender than the workers and possessing short wing-rudiments or wing-buds.* These nymphs are often present in great numbers and appear to be destroyed and stored for food when

* The term "nymph" is used in this paper to denote the young of reproductive forms in which the wing rudiments are evident. The word "larva" is used to denote all apparently undifferentiated young.

produced in excess of requirements. The survivors may develop into sexually mature insects of four kinds, namely, neoteinic, or supplementary, kings and queens or true kings and queens. In the former (neoteinics) the wing-buds undergo very little further development, and the eyes and chitinous parts become only partly pigmented. After fertilisation the abdomen of the female becomes greatly enlarged, and she is capable of laying a great number of eggs, which, in this species at any rate, produce individuals of all castes. Those nymphs that are destined to develop into true kings and queens continue to develop the wing-buds until, after a final moult, they emerge as winged imagines, with pigmented eyes and chitinous parts.

In all of the many scores of termitaria examined, the reproductive forms found in each were either neoteinics only, or one true king, and from a few to over 100 neoteinic queens. True queens have not been found, nor have neoteinic kings been observed in any nest in which a true king was present; there are no queen cells or nurseries in these termitaria, the ordinary flattened horizontal cells being utilised as required. The ovigerous neoteinic queens are to be found scattered through all parts of the nest, but generally near the walls. Each queen appears to preside over a restricted area, in which the eggs and young larvae are to be found, the latter in one or more small clusters about the size of a large pea. As the larvae develop they spread out in all directions, mixing with the soldiers and workers. The king is rarely associated with one of these queens; more often he is to be found in one of the larger cells with from 10 to 40 younger queens of various sizes, some only recognisable as such, others apparently as fully developed as the egg-laying individuals. Neoteinic kings, when present, occupy these cells and have not been found in cells occupied by isolated queens. It appears that, as a rule, queens are fertilised and attain nearly their maximum development before they migrate to other parts of the nest to oviposit, and that they are not often re-fertilised from time to time, as is believed to be the case with true queens of other species. The fact that old neoteinic queens, *i.e.*, queens with shrunken abdomens, have not been found in this species and that males are very rarely found with isolated queens, suggests that normally a queen does not mate after she begins egg-laying and that she is destroyed and replaced by a more fecund one as soon as she has passed her prime.

Prior to the final moult, which takes place about November, pigmentation in the nymphs of the first form is confined to the eyes. The wing-buds are short and thick outgrowths from the posterior margin of the meso- and metathorax, measuring about 3 mm. in length. After the moult the wings appear as soft, white, crinkled membranes, which rapidly assume their full length, but remain unpigmented, like the rest of the body, for some days. The duration of the period intervening between the moult and acquisition of the full degree of pigmentation of the chitinous parts and functioning wings is not known, but it appears to be about 10-14 days. Moulting does not take place simultaneously in all the individuals which are destined to take part in the colonising flight, many being still in the final nymphal stage while others are capable of flight. Indeed, some individuals do not develop functioning wings until after the flight. Whether the true king, which is so often found with the neoteinic queens in the termitarium, is developed from one of these, or from one of the earlier matured imagines, or whether he is the original male parent of the colony, is not known. The latter, however, is most improbable, since he rarely, if ever, possesses blunted claws and pigmented apices to the tarsi, which are the indications of age in mature queens. Further, many of the termitaria are evidently very much older than the longest period suggested as the probable life of this caste.

The life of the winged imago within the termitarium is short, and is certainly regulated to a considerable degree by weather conditions, that is, swarming does not occur before the first heavy rain of the season has fallen and the ground is thoroughly moistened.

It has been stated above that true kings, *i.e.*, de-alated, sexually mature imagines, are often found in the nests as consorts of neoteinic queens, but true queens are unknown in this species. The questions that naturally arise are: What becomes of the countless thousands of female imagines (potential queens) which issue yearly from most, but not all, termitaria? Do none of them become the founders of new colonies, as is the case with many species? Is this species perpetuated solely by neoteinic queens and true kings or neoteinic kings? It is beyond doubt that the vast majority of individuals of a colonising flight, *i.e.*, potential true kings and queens, succumb to the attacks of predacious ants, lizards and birds within a few minutes of the commencement of their free life, but it is hardly conceivable that all are irretrievably lost. Observations made during a period of two years, during which many scores of nests have been examined at fairly frequent intervals, convince me that the normal manner of reproduction is by the forms commonly found in the nests, *i.e.*, true and neoteinic kings and neoteinic queens. In seeking an explanation for the apparent non-existence of true queens, one suggests itself as being the most probable, namely, that the life of the winged forms, and probably of the workers and soldiers also, is short, perhaps about two years in the case of the former, that a small proportion escape destruction at the time of the colonising flight, mate and become the parents of the colonies which for some time live in galleries in the soil. Later, these colonies increase to such size that the construction of a termitarium becomes possible, or perhaps necessary; in the meantime, however, the founders have lived their lives and their place in the community has been taken by neoteinics derived from nymphs. This theory does not account for the presence of young true kings in old termitaria, except in the manner suggested in a previous page, nor does it explain why, if male imagines are sometimes retained in the community to be the consorts of neoteinic queens, female imagines also are not retained to obviate the necessity for bringing neoteinic queens into use. Explanations of these and other phenomena in the economy of termites present difficulties which can be overcome only by prolonged and careful field observations.

The invasion of these termitaria by the common ant, *Iridomyrmex sanguineus*, Forel, has been referred to in discussing the biology of *Drepanotermes silvestrii*, sp. n.

Hamitermes perplexus, var. victoriensis, nov.

King.—Colour as in *H. perplexus*, sp. n., excepting that the antennae and tergites of the abdomen are lighter (Dresden brown); sternites Dresden brown, the first five distinctly darker at the sides than elsewhere, 6th–8th uniformly dark, no pale marks visible; the first seven tergites only have pale marks at each side, more or less indistinct excepting on 3–6 inclusive; sternum and pleurae argus brown.

Head as in *H. perplexus*, excepting as follows: Ocelli smaller, fontanelle smaller, linear extension rather longer. Thorax as in *H. perplexus*, except that the two smaller lateral impressions on prothorax and the clear marks on metathorax are wanting. Legs as in *H. perplexus*. Abdomen as in *H. perplexus*, excepting as noted above. Measurements as in *H. perplexus*.

Neoteinic Queen.—Head, thorax and wing-stumps light orange-yellow, sternites and tergites of abdomen of the same colour; remainder of abdomen and legs creamy; the whole insect clothed with fine, pale hairs.

(a) Head longer than wide. Eyes small (0.18), pigmented in centre. Ocelli small, situated as in king. Antennae 14-jointed, segmented as in king. Fontanelle not a depression, but a broadly lanceolate scar, with a short straight median line. Thorax as in king, wing-pads of metanotum extending to the middle of the third tergite. Legs with tibial spurs worn down to short, blunt stumps. Apices of the first three tarsals heavily chitinated. Styli absent. (This appears to be a normal queen of the second form.)

Measurements: Total length, 12; head, with mandibles, 1.5 long, 1.22 wide; prothorax, 0.65 long, 1.12 wide; abdomen, 3.25 wide.

(b) Gross appearance similar to that of (a). Labrum very short, exposing the two apical teeth of both mandibles. Anteclypeus invisible. Eyes and ocelli as in (a). Antennae 15-jointed. Fontanelle a large cone-shaped *projection*. Wing-pads of metanotum extending to the base of the second abdominal tergite. Styli absent. (This is evidently an abnormal form.)

Measurements : Total length, 7·25 ; abdomen, 2 wide.

Soldier very similar to *H. perplexus*. Labrum slightly more rounded ; clypeus rather narrower and more deeply emarginate ; antennae inserted nearer the outer margin of head, first two joints not so long and slender ; mandibular teeth rather more hook-like ; gula as seen in dotted line (fig. 21).



Fig. 21. *Hamilermes perplexus*
var. *victoriensis*, nov., head of
soldier.

Measurements : as in *H. perplexus*.

Worker.—As in *H. perplexus*.

VICTORIA: Preston (*F. E. Wilson*).

The differences between the Victorian and Townsville specimens are very slight indeed, but appear to me to be sufficient to justify one in separating the former as a variety of the latter.

Biology.

This variety is described from two small colonies found under stones. The first colony was taken on 14th November and comprised a few larvae, soldiers, workers, nymphs of the second form and the neotenic described above. The eyes of the nymphs are small and very little pigmented, the ocelli are rudimentary, the antennae 15-jointed as in the imago, and styli are present in both sexes. Worker-like individuals of whitish colour and slender form I consider to be immature reproductive forms in the stage prior to the development of the wing rudiments.

The second colony was taken in September and comprised larvae, soldiers, workers, nymphs of the second form and a true king. Neither a true nor a neotenic queen was found. It appears to be a rare form and the first of the genus to be recorded from Victoria. There are no termitaria of any kind in the district.

***Hamitermes neogermanus*, sp. n.**

Soldier.—Head and base of mandibles orange, mandibles ferruginous at the tip; antennae mars yellow, darker than head; remainder of insect pale stramineous.

Head and mandibles (fig. 22) together twice as long as wide, rounded behind and on the sides. Mandibles very long, falciform, with a sharp hook-like tooth before the middle. Labrum almost as long as wide, rounded in front. Clypeus large, wide, with median shallow depression not reaching the posterior margin. Antennae 15-jointed, long and slender; 1st joint long and narrow, twice as long as 2nd; 2nd cylindrical; 3rd short and narrow, smallest of all; 4th and 5th alike, about twice as long as 3rd; 6th longer, nearly as long as 7th; 7th–12th alike; 13th and 14th a little longer; 15th rather longer than 14th, bluntly pointed.

Prothorax shaped as in *H. perplexus*, sp. n., with scattered long red hairs. Legs moderately slender, similar to those of *H. perplexus*, fore-tibiae with a row of long and stout hairs on the lower side of the apical half.



Fig. 22. *Hamitermes neogermanus*,
sp. n., head of soldier.

Abdomen wide in the middle, tapered to the pointed apex. Cerci short.

Measurements: Total length, 5.5; head and mandibles, 2.16 long; head, 1.17 wide; mandibles, 1 long; antennae, 2.03; thorax and abdomen, 3.5 long; prothorax, 0.42 long, 0.7 wide; tibia (i) 0.92, (ii) 0.84, (iii) 1.17.

Worker.—Head and thorax pale stramineous; antennae much darker towards the apex; remainder of insect whitish, clothed with red hairs.

Head rounded behind, rather straighter on sides than usual. Labrum large, narrower at the base than across the middle. Anteclypeus large, produced in front. Postclypeus large, convex, truncate in front, rounded behind. Antennae 15-jointed; 1st joint twice as long as 2nd; 3rd very short and narrow, smallest; 4th and 5th about equal to each other; 6th larger; 7th–15th increasing in length gradually.

Prothorax with anterior portion rounded and bent up, antero-lateral angles rounded, posterior margin rounded, with slight emargination, clothed with long and short red hairs. Legs rather short and slender.

Abdomen elongate-oval, clothed with red hairs. Cerci with basal portion short and broad, remaining two-thirds slender.

Measurements: Total length, 5.25; head, with mandibles, 1.5 long; head 1.12 wide; antennae, 1.41; thorax and abdomen, 3.76 long; prothorax, 0.37 long, 0.84 wide; tibia (i) 0.86, (ii) 0.7, (iii) 1; abdomen, 1.8 wide.

This species is most closely related to *H. germanus*, Hill, from the Northern Territory (fig. 19); it differs, however, in its much larger size, larger and more rounded labrum, and larger and differently shaped clypeus. In both species the antennae are similarly segmented and the mandibles are alike except in size. The two species are easily separated.

Described from one soldier, and numerous nymphs and workers in alcohol, and nine soldiers and nine workers on cards.

Type series in South Australian Museum; co-types in author's collection.

SOUTH AUSTRALIA: Mt. Lofty Ranges (*N. B. Tindale*); Gawler (*A. M. Lea*); Angaston (*A. M. Lea*).

***Hamitermes eucalypti*, sp. n.**

Imago.—Palpi and legs buckthorn-brown; head, thorax, wings, abdominal tergites mummy-brown, head darkest, antennae Dresden brown, darker towards the tip.

Head (fig. 23) rounded, slightly longer than wide, widest across the eyes, densely clothed with moderately short hairs. Maxillary palpi with first and second joints very short, together equal to the third; third and fourth equal. Eyes large, rounded, projecting well beyond sides of head. Ocelli large oval, separated from the inner margin of the eyes by a distance equal to their length. Fontanelle large, broadly lanceolate, twice as long as wide.



Fig. 23. *Hamitermes eucalypti*, sp. n., head of imago.

Antennae 15- or 16-jointed, dark with clear articulations; 1st joint twice as long as 2nd and much wider; 2nd cylindrical and about as long as 3rd and 4th together; 3rd very short, narrower than 2nd and 4th, indistinctly separated from the latter; 5th and 6th equal in length and shorter than 7th and 8th; 9th to 13th longer than 7th and 8th and nearly equal to each other; 14th slightly longer than 13th; 15th and 16th a little longer than 14th; 15th cylindrical.

Prothorax slightly bent up in front, rounded on the sides to the truncate posterior margin, a clear oblique oval area on each side of the median suture in the anterior third, the whole surface moderately densely clothed with medium-sized hairs. Wing-stumps small, triangular, clothed with numerous short and long hairs, suture straight;

margin of wing (fig. 24), excepting proximal fourth of posterior border, ciliate, with scattered hairs on membrane, especially on apical half and along veins; costa, radius, base of median and first seven or eight branches of cubitus very distinct, branches of cubitus sometimes anastomosing to form cells. Legs with femora moderately stout; tibial spurs, 3:2:2.



Fig. 24. *Hamitermes eucalypti*, sp. n., wings of imago.

Abdomen long and nearly cylindrical, with 10 dark tergites, each of the first eight very distinct and with a small clear spot towards each lateral margin, moderately hairy; eight distinctly visible sternites, pale except at the lateral margins, where there is on each side a dark spot, sixth longest and darkest. In the male there are seven distinctly visible sternites, with lateral spots on the first three, the remainder nearly uniform in colour; lower surface darker than in female. Cerci short, basal portion as long as apical.

Measurements: Length with wings, 11-12; length without wings, 6.5-8; head, with mandibles, 1.2-1.3 long; head, at and including eyes, 1.1 wide; mandibles, right, 0.6-0.62 long, 0.46 wide, left, 0.65-0.67 long, 0.35-0.37 wide; antennae, 1.65; prothorax, 0.47 long, 0.98 wide; fore- and hind-wings, 9.25 long; fore-wing, 2.58 wide; hind-wing, 2.68 wide; tibia (i) 0.7-0.75, (ii) 0.8, (iii) 1.1-1.13.



Fig. 25. *Hamitermes eucalypti*, sp. n., head of soldier (a) from above; (b) in profile.

Soldier.—Head ochraceous, mandibles ferruginous, labrum whitish; thorax lighter than head; abdomen and legs very light yellow.

Head with mandibles (fig. 25) longer than wide, rounded behind and on the sides, with scattered red hairs. Labrum convex, widest at the base, sloping to the bluntly

pointed apex. Clypeus convex, much wider than long, arcuate in front, divided by a deep median suture which extends into the front of the head, where there is a flask-shaped depression. Mandibles long and moderately slender, falciform, with a sharp hook-like tooth near the middle. Antennae 15-jointed, arising from a prominence within a short and wide fossa behind the base of the mandibles; 1st joint very large, 2nd less than half as long as 1st and much narrower; 3rd very short and narrow; 4th and 5th equal in size, longer and wider than 3rd; 6th much longer and wider than 5th.

Thorax with anterior half bent up, lateral margins angular, posterior margin rounded, clothed with scattered reddish hairs as on head. Legs with femora moderately stout, fore-tibiae stout, mid-tibiae with two short stout setae towards the apex in addition to the two larger apical spurs; tibial spurs, 3:2:2.

Abdomen clothed rather densely with reddish hairs.

Measurements: Total length, about 4; head, including mandibles, 1.78-1.8 long; thorax and abdomen, 2.8 long; head, 1.03-1.12 wide; antennae, 1.41; prothorax, 0.32 long, 0.7 wide; tibia (i) 0.8, (ii) 0.7, (iii) 1; abdomen, 1.17 wide.

Worker.—Head and thorax creamy, rest of insect almost hyaline, the whole surface moderately hairy.

Antennae 15-jointed; 1st joint twice as long as and one-fifth wider than 2nd; 3rd very short and narrow, shorter than broad; 4th and 5th equal in length, longer and wider than 3rd; 6th as long as 2nd; 7th-12th similar to each other, longer than 6th; 13th and 14th equal in length, the latter more cylindrical; 15th as long as 1st, widest at the proximal third, tapered to the pointed apex.

Prothorax with anterior third rounded and bent up, emarginate; lateral margins elongate, bluntly pointed; posterior margin truncate, without emargination; surface clothed with stout reddish hairs. Legs similar in shape and armature to those of soldier, except that the two short setae on the upper surface of the second tibiae of the soldier are replaced by much longer and more slender ones; tibial spurs, 3:2:2.

Measurements: Total length, about 5.2; head, with mandibles, 1.41 long; thorax and abdomen, 3.76 long; head, 1.04 wide; mandibles, right, 0.51 long, 0.42 wide, left, (a) 0.51 long, 0.3 wide, (b) 0.61 long, 0.37 wide; antennae, 1.4-1.7; prothorax, 0.37 long, 0.75 wide; tibia (i) 0.7, (ii) 0.65, (iii) 0.90-0.93.

This species appears to be nearest *H. herbertensis*, Mjöb., from which it is easily distinguished by the characters given for the imago and soldier.

N. QUEENSLAND: Magnetic Island, Townsville.

Biology.

This is a common species in the Townsville district and on Magnetic Island, where it is generally found under earthy covered-ways on the trunks of living eucalyptus trees growing on hill-sides and open forest lands. Very rarely these covered-ways are constructed on the trunks of dead trees from which the bark has fallen; but in most cases living trees with friable bark are favoured. At first, tube-like covered-ways are constructed, which extend up the trunk to a height of 6-10 ft., the loose, weathered surface being removed as the tube progresses upwards. Later on these tubes are extended laterally until a considerable surface is encased. On removal of this fragile casing the outer weathered surface of the bark beneath will be found to have been removed—apparently for food. On one occasion a very small and inconspicuous mound of earth, unlike a true termitarium, lay at the base of the tree, and from it the casing extended up the trunk for a distance of 3½ ft., where it had been cut off. The mound was traversed by a few galleries, which contained a few soldiers, workers, and nymphs of the second form (18.viii.1919).

The trunk, which was hollow, was sealed up on top with earth. When a portion of the wood was cut away, the interior was found to be nearly filled with earthy material, pierced by a few galleries, which contained the castes found in the mound. Four months later (15.i.1920) *Coptotermes* (?) *lacteus*, Frogg., was found in possession of the trunk and had commenced to build a typical termitarium on the site formerly occupied by the small mound referred to above. *H. eucalypti* was found under the casing on the bark and in tunnels in the adjacent soil; in the latter were also three winged adults. It appeared that the invading *Coptotermes* were the survivors from a large termitarium 6 ft. distant, which had been destroyed on 18th August 1919.



Fig. 26. Vertical tubes constructed by *Hamitermes eucalypti*, sp. n., prior to swarming.

On 25th November 1920, at Magnetic Island, near Townsville, the trunk of a large bloodwood tree (*Eucalyptus*) was found to have its sunny side almost encased in an earthy crust, under which were found many workers and a few soldiers of this species. Nearer the ground a few adult winged forms were found. Arising from the sandy soil near the trunk and within a space of a few feet were about a dozen vertical tubes (fig. 26), ranging from 5-23 cm. in height by about 1-3 cm. in diameter, which communicated each with an irregular chamber about 25 cm. long by 1½ cm. wide,

and these again with a system of small tunnels extending downwards to a depth of about 25 cm. Workers and soldiers only were found in the tubes, but numerous imagines and a few nymphs with short wing-pads were collected in the chambers and galleries. The latter appeared to be nymphs of the second form, *i.e.*, nymphs which would mature into queens and (?) kings of the second form (supplementary royalties). On 4th December a few winged adults were captured at a lamp in this locality.

From my observations I conclude that termites of this species do not construct termitaria, but rear their young and reach maturity in underground galleries. The vertical tubes and adjoining chambers are constructed just before the winged forms reach maturity and for the purpose of enabling these forms to assemble and disperse unmolested by predatory ants and other ground-frequenting enemies. The advantage of these tubes will be apparent to anyone who has witnessed the decimation of the winged forms of certain other species, which make their exit at the time of swarming by an opening made in the surface of the soil. Elsewhere in this paper reference is made to similar tubes constructed by *Hamitermes perplexus*, sp. n., which normally builds termitaria, but which frequently lives in underground galleries, as does *H. eucalypti*.

***Leucotermes clarki*, sp. n.**

Imago.—Upper surface buckthorn-brown, seven hindmost abdominal tergites a little lighter; mouth-parts and lower surface testaceous; abdominal sternites not distinctly darker; wings brown, apical half near costa and radius darkly shaded. The whole insect densely clothed with short reddish hairs.

Head (fig. 27) large, wider than long, widest at eyes. Fontanelle elongate, widest behind, two oblique clear impressions on either side in front midway between anterior end of fontanelle and posterior margin of clypeus; an indistinct suture extending posteriorly from fontanelle. Eyes very large, circular (0.28 dia.), projecting well beyond sides of head. Ocelli large, nearly circular, half as wide as eyes, from



Fig. 27. *Leucotermes clarki*,
sp. n., head of imago.

which they are separated by a rather narrow space. Anteclypeus very small, one-fourth as long as postclypeus, whitish, produced in the middle. Postclypeus large, paler than rest of head, darker than antennae, convex above, slightly curved in front, more so behind, twice as wide as long, divided medially by a narrow dark suture. Antennae 15- or 16-jointed; in 15-jointed antennae, 1st stout, twice as long as and much wider than 2nd, 3rd smallest, 4th and 5th equal, 6th–12th increasing slightly in length, 13th longer, 14th about as long as 13th but more cylindrical, 15th elongate-oval; in 16-jointed antennae the 3rd joint of the other form is divided into two, the first joint is generally more slender; the 3rd joint is very small and fused with the 4th, which is only a little larger.

Thorax moderately flattened above, rounded, slightly bent up and emarginate in front, rounded on the sides, narrowed to the slightly emarginated posterior border, divided medially by a suture, two clear transverse impressions behind the upturned anterior margin. Legs slender; tibial spurs, 3:2:2.

Wing-stumps triangular, suture straight, margin ciliate except at base of posterior border, scattered hairs over entire surface of membrane. In the fore-wing (fig. 28) the median vein branches from the radius within the wing-stump; in the hind-wing the branch is distinctly beyond the cross suture; radius very dark, darker than other veins, shaded above and below beyond the middle; median nearer the cubitus than the radius, dark at the base only, unbranched or with a variable number of indistinct branches near the apex; if branched, the branches joining the wing margin at or above the apex; cubitus with 9-12 branches, the first 4-8 dark and often branched, the remainder lighter, simple or branched once or twice, all reaching the posterior margin.

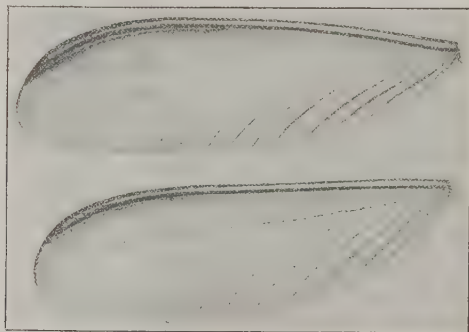


Fig. 28. *Leucotermes clarki*, sp. n., wings of imago.

Abdomen elongate, very little widened in the middle, bluntly rounded at apex; sternites 1-7 with clear spot at each end; cerci short, basal portion as long as apical.

Measurements: Total length, about 7; head, with jaws, 0.99-1.17 long; thorax and abdomen, 5.57 long; head, at and including eyes, 1.2 wide; antennae, 1.7; mandibles, right, 0.61 long, 0.43 wide, left, 0.66 long, 0.37 wide; prothorax, 0.6 long, 0.99 wide; fore-wing, 12.5 long, 3.66 wide; hind-wing, 11.5 long, 3.8 wide; tibia (i) 0.89, (ii) 0.89, (iii) 1.17; abdomen, 1.64 wide.

Soldier.—Head bright yellow, palest behind; mandibles dark ferruginous to bright yellow; labrum and antennae bright yellow; pro-, meso- and metathorax pale yellow, like back of head, remainder of insect whitish. Head, margin of thoracic tergites, and abdomen with scattered, moderately strong, reddish hairs.

Head (fig. 29) long, parallel on the sides, rounded behind. Mandibles long, moderately stout, of typical form. Labrum long and wide (0.47 long, from anterior margin of clypeus, by 0.35 wide across the middle), slightly swollen on the sides, narrowed to the pointed apex. Anteclypeus very short, hardly visible. Postclypeus nearly twice as wide as long, truncate in front. Fontanelle present. Maxillary palpi with first and second joints half as long as third and fourth; fifth slightly shorter than fourth. Antennae 16- or 17-jointed; in 16-jointed antennae, 1st joint stout, twice as long as 2nd; 3rd shorter and narrower than 4th, shortest; 4th as long as 2nd, swollen; 5th shorter than 4th; 6th as long as 4th; 7th longer;

in 17-jointed antennae the segmentation is as described in the imago. Gula (see dotted line in fig. 29) long and narrow, narrowest in the middle, expanded at the anterior fifth to twice the width at middle, anterior extremity slightly wider than middle.

Prothorax (fig. 29) a little narrower than head, as wide as metathorax, rounded and deeply emarginate in front, rounded antero-laterally, sides narrowed to the rounded and emarginate posterior margin. Meso- and metathorax rounded on the sides and behind, hind margin slightly emarginate. Legs short and stout, hind femora very stout; tibial spurs, 3:2:2.

Abdomen broad, a little wider in the middle than at the base. Styli very long and slender, apparently always present. Cerci long and slender.

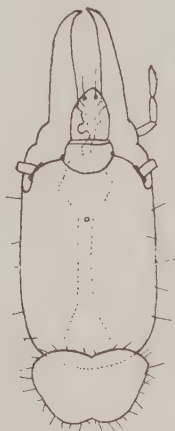


Fig. 29. *Leucotermes clarki*, sp. n., head of soldier.

Measurements: Total length, about 6; head and mandibles, 2.92-3.25; head, without mandibles, 1.65-2.1; mandibles from base, 1.4; head, 1.08-1.22 wide, 1.03 deep; head, base to fontanelle, 1.17; antennae, 1.7; thorax and abdomen, 3-3.25 long; prothorax, 0.6-0.66 long, 0.84-0.98 wide; tibia (i) 0.7-0.8, (ii) 0.61-0.65, (iii) 0.98-1.03; abdomen, 0.94 wide.

Worker.—Head and thorax pale yellow, a large ferruginous spot at either end of postclypeus, rest of insect whitish. Head and body sparsely clothed with reddish hairs.

Head rounded behind, widest across the middle. Anteclypeus small, whitish with a yellow mark on either side, one-third as long as postclypeus, rounded in front. Postclypeus large, convex, a little more than twice as long as wide. Antennae 14- or 15-jointed.

Prothorax rounded, bent up in front and slightly emarginate, sides narrowed to the posterior margin. Legs short and stout, third femora not greatly enlarged; tibial spurs, 3:2:2.

WESTERN AUSTRALIA: Swan River, Dwellingup, Ludlow (*J. Clark*).

Type series in author's collection; co-types in Mr. J. Clark's collection.

This species is most nearly related to *Leucotermes ferox*, Frogg. (fig. 30), a co-type (alate) of which I have examined, but it is easily distinguished by its larger size, darker colour, much darker and larger wings, larger eyes and fontanelle and short broad head. The soldier is larger than that of *L. ferox*. In *L. validus*, Hill, as in *L. paradoxus*, Frogg. (fig. 31), ocelli are wanting in the imago, the fontanelle is minute and set far back on the head, and the wings are much paler.

Silvestri (1909, figs. 127, 130 and 132) refers certain large-sized soldiers from Western Australia to *L. ferox*, Frogg., which I think are most probably referable to *L. clarki*, sp. n. The soldiers of all the species mentioned above are very similar and in most cases I have failed to find any reliable distinguishing characters; for this reason I have withheld descriptions of apparently distinct species from Queensland, Victoria and Western Australia until winged forms are available for study.

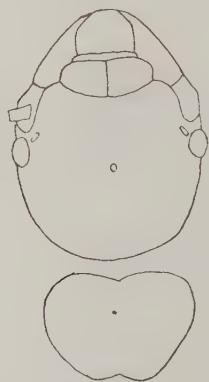


Fig. 30. *Leucotermes ferox*, Frogg., head and prothorax of imago; from a co-type.

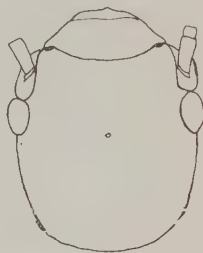


Fig. 31. *Leucotermes paradoxus*, Frogg., head of imago; from a co-type.

Biology.

Described from a few imagines, soldiers and workers taken on 13th May from a small mound about 12 in. high, and from numerous soldiers and workers taken in September of the same year.

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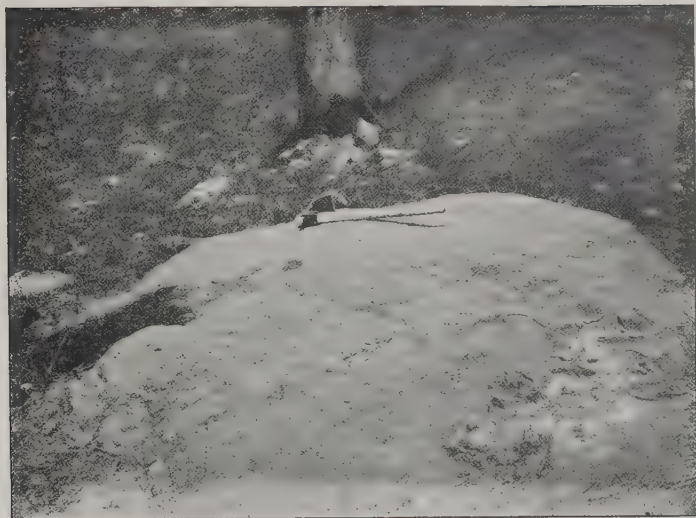


Fig. 1. Termitarium of *Drepanotermes silvestrii*, sp. n.



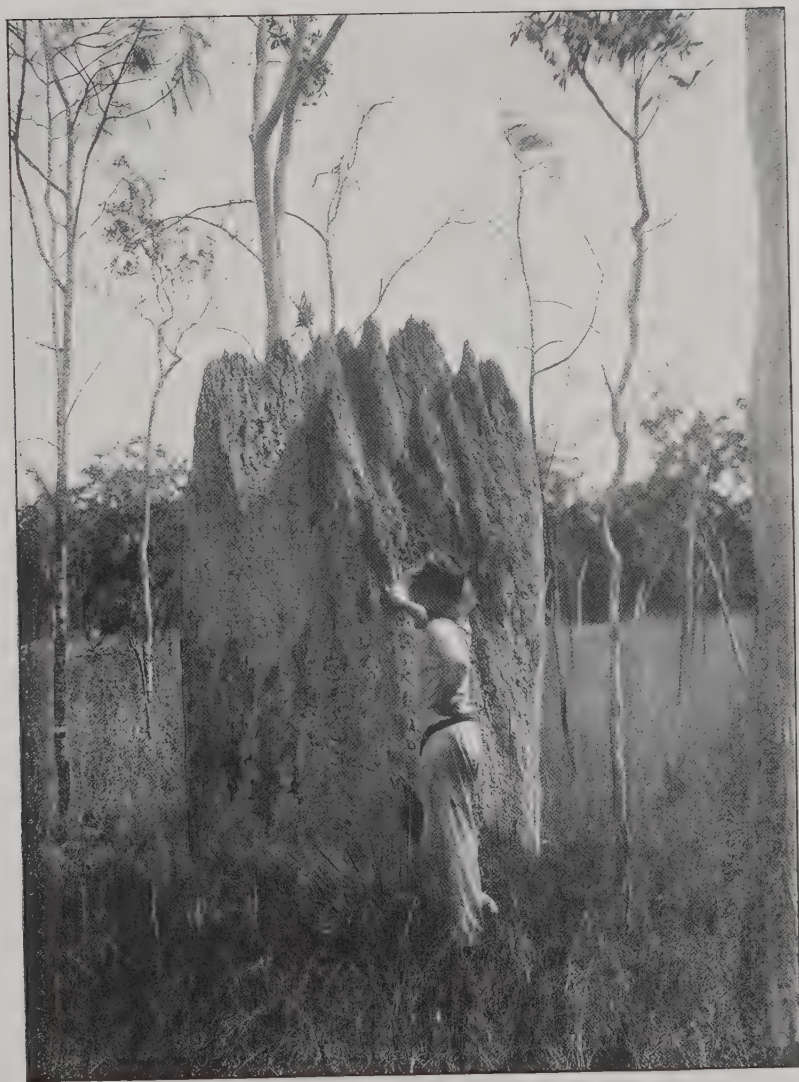
Fig. 2. Termitarium of *Drepanotermes silvestrii*, sp. n.,
showing internal structure.



Fig. 1. Termitarium of *Hamitermes perplexus*, sp. n., built on rocks.



Fig. 2. Form of termitarium of *Hamitermes perplexus*, sp. n., built on open plains.



Termitarium of *Hamitermes meridionalis*, Frogg., near Darwin, Northern Territory, Australia.



Fig. 1. An unusual type of termitarium of *Hamitermes perplexus*, sp. n. The track in the foreground has been made by an invading army of ants (*Iridomyrmex*).

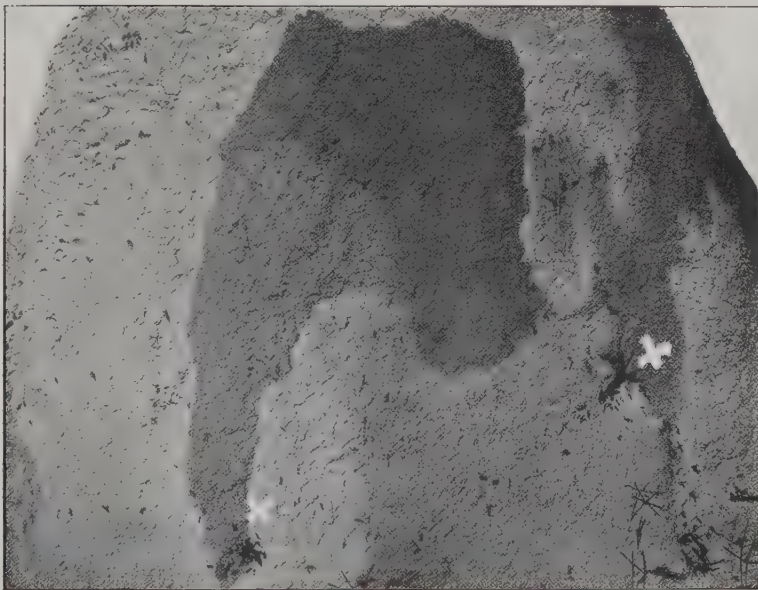


Fig. 2. Termitarium of *H. perplexus* invaded by *Iridomyrmex*, which have entered at holes marked X. The dark portions have been recently added by the termites.

THE MOSQUITOS OF SOME PORTS OF CHINA AND JAPAN.

By W. A. LAMBORN,

Malaria Bureau, Federated Malay States.

A mosquito survey, having as its object an enquiry into the distribution and prevalence in certain Far Eastern Ports of *Stegomyia fasciata*, the known carrier of yellow fever, was begun, on behalf of the Imperial Bureau of Entomology, by Dr. A. T. Stanton, whose report was published in the Bulletin of Entomological Research (Vol. x, pt. 3). As it seemed unlikely that he would be at leisure to complete the observations by a survey of the ports of China and Japan, as had been planned, the writer was instructed, in April 1921, by the Government of the Federated Malay States, at the suggestion of the Imperial Bureau, to complete the enquiry.

The following ports were accordingly visited with this object between April and June: Fuchow, Shanghai, Nagasaki, Kobe and Yokohama. The object of the present report is to afford an account of the investigation and of the observations made.

In a latitude so far north as that in which the enquiry was commenced, namely $26^{\circ} 8' 4''$, it was hardly to be anticipated that a considerable variety of mosquitos would occur; nor at the season, early spring, were great numbers of imagos to be expected. So difficult indeed was it to discover any at all, that it was found necessary to abandon the attempt to determine the presence of mosquitos by capture and to concentrate on the investigation of possible breeding places, a method the surer on account of recent experience, especially in the Malay States, of the breeding habits of the common CULICIDAE. By breeding, long series of adults were obtained, for it was found that the larvae of all species were little affected by the shaking they were subjected to in the course of travel, whether by land or sea. Thus the larvae obtained in Fuchow, China, afforded imagos fifteen days later in Nagasaki, in Japan; imagos were obtained in Yokohama from larvae taken fourteen days previously in Nagasaki, 853 miles to the south by rail; and imagos emerged on the steamer in Mid-Pacific, some 2,000 miles from land, from larvae taken eight days previously at Yokohama.

Fuchow.

Fuchow, the capital of the Fukien Province of China, is situated in latitude $26^{\circ} 8' 4''$ North and longitude $119^{\circ} 37' 7''$ East on the north side of the Min river at about 35 miles from its mouth. It is 140 miles north of Amoy and 280 south of Hangchow.

The Foreign Settlement is on Nantai, a small island formed by the parting and rejoining of the river and connected with the town on the mainland by an old stone bridge. The Chinese town itself, with a population estimated at 600,000, consists of a labyrinth of native buildings, largely one-storied, intersected in every direction by lanes, usually paved, and so narrow as to allow only foot traffic.

Except for a small hill partly occupied by the Foreign Settlement, which is hemmed in on all sides by the native quarters, the district is entirely flat and so little above water-level that with sudden rises of the river, which take place once or twice annually, the whole town becomes inundated. Rice-fields surround it on every side.

The river is crowded with craft of all descriptions, from large sea-going junks to small two-oar and other boats trading with the interior. The town is not accessible to ocean-going vessels other than junks, larger ships anchoring about twelve miles down stream, at Pagoda Anchorage.

Trade.—The trade of the port is mostly with other coastal places, for owing to trade depression, particularly in tea, for which until a few years ago Fuchow was one of the world's centres, large ships rarely put in. As showing how great has been the falling off in trade, it may be mentioned that, whereas in 1893 the total export of tea was 65,794,894 lb., it had dwindled to only 6,941,877 lb. by 1918.

Steamers, mostly European-owned, run to and from Hong Kong, while the steamer trade to Shanghai is largely in the hands of the Chinese. During a part of the year motor schooners, trading under the Japanese flag, run to and from Formosa, and a very occasional ship brings kerosene from San Francisco.

Climate.—The seasons correspond roughly with our own, the summers being as a rule excessively hot, while in winter, when snow may fall, an icy blast sweeps down over the hundreds of miles of flat treeless country to the north. No data as to rainfall were available.

Water Supply.—There is no public supply. Water is usually taken from the Min at low tide and is slightly brackish, but there are a few surface wells in the graveyards, the only open spaces in the city. As is usual in native towns without a pipe supply, water is stored in large earthenware jars, which are also used for collecting rain-water.

Sanitation and Quarantine.—Such sanitation as is attempted appears to be due entirely to the demand for excreta for agricultural purposes. Scavengers, usually women, carrying uncovered wooden buckets, make a house-to-house collection day by day, and from time to time bale out the contents of earthenware jars disposed in odd corners for the convenience of passers-by, and vie with each other in seeking to obtain for sale such casual deposits as may be promiscuously made elsewhere. The material, after long storage in primitive septic tanks, is dumped on the rice-fields. The effect of this pollution on mosquito breeding would seem to be a point well worth determining. Other waste water is either thrown directly into the street, or, escaping under the walls of the houses into a pit on the outside, forms possible breeding places. No measures against mosquitos are in force.

A European Medical Officer, under the Chinese Maritime Customs, is stationed at Pagoda Anchorage; all ocean-going ships are subject to his inspection and he is able to enforce quarantine there.

Such hospitals as there are in the town, with a total of about 250 beds, are connected with the various Missions, which in the past have attempted to deal with any epidemics that have arisen. During the outbreak of cholera in 1919 which, it is estimated, resulted in the death of no fewer than 40,000 people, a large number of temporary hospitals were erected by the American Red Cross.

Mosquitos.—The following is a list of the mosquitos obtained: *Stegomyia albopicta*, Skuse (= *scutellaris*, Theo.), *Culex fatigans*, Wied., *C. tritaeniorhynchus*, Giles, and *A. hyrcanus*, Pall. (= *sinensis*, Wied.).

Stegomyia albopicta.—The larvae of this species teemed in all water-jars left standing. These seemed to be the only breeding places available to the insect, which favours artificial breeding places; for the thrift of the Chinese leads them to collect all old tins, broken bottles and similar receptacles, such as in the vicinity of habitations in the Federated Malay States afford abundant opportunities for the insect.

It was usually possible to determine the species of larvae in particular vessels by examination of the adults found newly emerged on the inside at almost any hour of the day. But although long series of larvae were collected from numerous places, no single specimen of *S. fasciata* was obtained.

Culex fatigans.—The larvae of this species swarmed in the foul-smelling waste water from houses, and in certain ponds which had once been used for fish cultivation

but have since served as dumping grounds for all sorts of organic refuse, chiefly of vegetable origin. They were also found sparingly in several places in ill-smelling water in pans placed under flower-pots. The species was certainly the dominant one in the town.

Culex tritaeniorhynchus.—The larvae of this species were found sparingly in the rice-fields associated with those of *A. hyrcanus*.

Anopheles hyrcanus.—The larvae of this insect were found in fair abundance on the outskirts of the town in the rice-fields, then at an early stage of cultivation, the planting out of the young plants from the nursery beds having only just commenced. It was noteworthy that in these beds, longer undisturbed than the open fields, the larvae were far more numerous than in the newly planted fields, possibly by reason of the presence of a larger amount of green filamentous algae, on the tufts of which they were invariably found. The larvae were either green in colour, or green with white splashes; or banding was present to a varying degree on the thorax, 3rd, 5th and 8th segments. They did not present that considerable diversity both of colour and pattern seen in those of the Malay States. Though they rested on a green background, it was easy to see them when the sun's rays were oblique, but difficult to do so with the sun overhead.

Shanghai.

Shanghai, the great emporium of Central China and its most important free port, is situated in latitude $31^{\circ}14'$ North and longitude $121^{\circ}29'$ East on the left or west bank of the Huangpu River, about twelve miles above its junction with the Yangtze and at a distance of sixty miles from the North Saddle light at the river mouth.

Three distinct areas, each having its own municipal council, comprise the port, namely, the International Settlement, the French Settlement and the Chinese City. The area within the municipal limits is $8\frac{3}{4}$ square miles, and the quinquennial census of the foreign and Chinese populations residing within the limits and of foreigners living on the outside roads, which was taken on 10th October 1920, showed a total of 26,869 foreigners and 1,661,098 Chinese. Among the foreign population the Japanese were dominant, numbering 10,215; the British coming next and numbering 5,341. The figures do not include a vast Chinese population residing outside the Settlements.

The country round Shanghai, which is devoid of trees, is perfectly flat, stretching as a rich alluvial plain to the west over 45,000 square miles. The area round the town is little above sea-level, so that it does not present a great variety of possible breeding places for mosquitos.

Trade.—Shanghai is not only a port of trade, but is a large manufacturing and industrial centre to which ships come from all quarters of the globe.

Temperature and Rainfall.—The annual mean temperature is about 50.9° F. In July and August it runs up to a mean of about 81° , and in January and February drops to a mean of 36° and 37° . In winter, snow and ice are occasionally seen, biting winds sweeping down from the north. A certain amount of rain falls throughout the year, the annual fall being about 39.97 inches, with a maximum fall of about five inches in June, July, December and February.

Water Supply.—The public supply for the International Settlement is drawn from the Huangpu, below the town; that for the French Settlement is obtained some distance above it. It is piped to most of the houses, or is obtainable from standpipes, so that there are practically no wells.

Sanitation and Quarantine.—The Health Department of the International Settlement, under British supervision, is a large one, consisting of a Director with three Assistant Health Officers, fourteen Sanitary Inspectors, and three Sanitary Overseers.

with a large native staff. Anti-mosquito measures are thoroughly carried out. For the purposes of mosquito reduction a special staff of Chinese coolies is organised from the middle of March until the end of October, and works under the direction of Inspectors, who make written notes of those places where stagnant water occurs, such as Chinese gardens, empty houses and defective gullies, such spots subsequently receiving special attention.

By means of posters and leaflets in the languages commonly spoken an endeavour is made to instruct the people as to the necessity for mosquito control, but the difficulties of this are enhanced by the supineness of the Chinese authorities controlling the part of the town outside the Settlements. Within the actual limits of these the search for mosquitos was fruitless; outside it the larvae of some dominant species were obtained abundantly, and it was said that mosquitos in the European part of the town are a nuisance, as a rule, only in the late summer, gradually extending in from the Chinese quarters.

The shipping and quarantine are under the control of the Chinese Maritime Customs. A medical officer visits ships when necessary and when they come from infected ports. The quarantine station, where hospital accommodation and fumigation apparatus are provided, is some miles down stream.

Mosquitos.—The following is a list of the species obtained: *Stegomyia albopicta*, *Culex fatigans*, *Culex tritaeniorhynchus*, *C. virgatipes*, Edw., and *Anopheles hyrcanus*. Three of these species, with *Armigeres ventralis*, Walk., are recorded in the report of the Health Officer of Shanghai for 1920 as having been collected in the course of examinations made by the staff. The two new records concern *C. tritaeniorhynchus* and *C. virgatipes*.

Stegomyia albopicta.—A search for four days in various parts of the International and French Settlements entirely failed to bring to light any larvae of *Stegomyia*. On the fifth day access was obtained, through the kind intervention of Mr. E. Kilner, Chief Sanitary Inspector, to a Chinese-owned greenhouse, standing by itself and not at that season artificially heated, where in the water under five out of eleven little fern-covered rockeries kept in pans the larvae of this species were for the first time obtained. They were subsequently found in one other similar situation, but a further search for them elsewhere was entirely fruitless. No other species of *Stegomyia* was obtained. The scarcity of this insect at that time may well have been due to inclemency of season, which was said to have been unusually cold throughout, the mean daily temperature during the stay of five days in Shanghai being 61°, a bitter northerly wind blowing.

Culex fatigans.—The larvae of this species were found in open drains from houses and in the trenches draining vegetable plots.

Culex virgatipes.—This species was found in the same breeding places with *C. fatigans*, but in greater abundance.

Culex tritaeniorhynchus.—A single female example of this species, of very large size, was bred from a pupa found in a small swamp associated with those of *A. hyrcanus*.

Anopheles hyrcanus.—The larvae of this species were obtained in fair abundance in foul and stagnant water in swamps on the outskirts.

Nagasaki.

Nagasaki is situated in latitude 32° 45' North and longitude 129° 52' East, at the head of an inlet some three miles long at the western extremity of the island of Kyushu, which is about 469 miles from Shanghai. Being the most southerly of the ports of Japan it is the first port of call of the eastward steamers from India, the South Seas, China and the Philippines. It is largely built at the foot of hills

forming a basin, but the houses extend up into the valleys to an elevation of about 400 ft. It has a population estimated at 176,480, and, in point of size, ranks next after Kobe in Western Japan.

Trade.—It is noted as a coaling station, the coal being obtained chiefly from Takashima, an islet eight miles south-east of the entrance to the harbour, and in lesser quantities from two adjacent islets.

There are no large industrial concerns in the south of Japan other than the shipbuilding yards at Nagasaki, and the exports are therefore small.

Temperature and Rainfall.—The climate is mild and equable, the mean annual temperature being from 60° to 63° F., with extremes of 40° to 45° in winter, and 75° to 85° in summer. Snow and frost are unknown.

Water Supply.—Mountain torrents supply the outlying parts of the town with water; the supply to the centre is pipe-borne from reservoirs in the hills near by.

Sanitation and Quarantine.—A quarantine station, with shore hospital accommodation and apparatus for the fumigation of ships, exists at a distance of a couple of miles to seaward of the harbour, and similar provision is made at all the other large ports of Japan.

Mosquitos.—A greater number of species than was met with in Fuchow and Shanghai was to be expected in Nagasaki, by reason of the more genial climate and the greater variety of breeding places afforded by the natural features of the country. The following species were obtained: *Stegomyia albopicta*, *Aedes (Finlaya) togoi*, Theo., *Aedes (Finlaya) japonicus*, Theo., *Culex fatigans*, *C. hayashi*, *C. tritaeniorhynchus*, *Armigeres obturbans*, Walk., *Lutzia vorax*, Edw., *Anopheles hyrcanus*, *A. lindesayi*, Giles, and *Anopheles punctibasis*, Edw.

Stegomyia albopicta.—The larvae of this species were fairly abundant in artificial breeding places, usually in shaded situations and in pure culture. They were obtained in rain-water collected in earthenware jars, in saucers beneath flower-pots, and in the cement or stone basins beneath the little fern-covered rockeries which are so commonly seen in Japanese gardens. An oblong granite trough, shaded by the eaves of a house in the main street, afforded a vast number of larvae, and similar troughs, set beneath a roof of thatch in the court-yards of temples and containing water for worshippers to rinse their mouths and wash their hands, preparatory to entering the sacred edifices, almost invariably afforded larvae. Their security in such situations is to be explained largely by the wariness exhibited, the larvae all dropping to the bottom on the slightest disturbance of the water, and by there being no means of draining the water from the bottom of the receptacles, which are never completely empty. A little bowl, scooped in the top of a granite pillar placed in front of a stone image of Buddha in a small roofed wayside shrine, afforded larvae, which were also found there in the water in sections of bamboos placed for the reception of votive offerings of flowers. No specimens of *S. fasciata* were obtained.

Aedes (Finlaya) togoi.—The larvae of this species were first obtained in enormous numbers in the centre of the town, on the hillside in a large uncovered cement tank holding some hundreds of gallons and used for the storage of rain-water. They were invariably found in the water-containing troughs cut in the solid stones forming the pedestals of the monuments in cemeteries, and in the granite vases, often of very large size, placed for ornamental purposes in gardens. Cups hollowed in boulders placed near the doors of houses, and containing water used for ablution purposes, often contained these larvae when in the open, and they were commonly found in water-containing hollows in rocks in partly dried-up beds of streams running down from the mountains through the town.

Aedes (Finlaya) japonicus.—This, unfortunately, was not recognised as a distinct species, until Mr. F. W. Edwards had made the determinations. It was found less abundantly than *Aedes togoi*, though breeding in similar places, and, it is believed, mixed with this species.

Culex fatigans.—The larvae of this species were found abundantly in foul drains and cesspits. Such was the cleanliness of the town, in spite of the absence of any water-borne sewage system, that these breeding places were not discovered at all within its precincts. Open drains were found only in the vicinity on the countryside, usually about cattle-sheds and rarely near houses. Pits, open to the sky, either dug in the ground or cut in the rock, were dotted about the fields, and served as septic tanks into which collections of excreta were dumped, the contents being finally withdrawn for the purposes of agriculture. In such pits, whether containing comparatively fresh or thoroughly decomposed material, the larvae invariably occurred in enormous numbers, in the former case in pure culture.

Culex hayashi.—The larvae of this species were found in great abundance associated with those of (*Anopheles punctibasis*) in a small natural pond, almost dried up and completely shaded at all hours by trees.

Culex tritaeniorhynchus.—The larvae of this species occurred, as elsewhere, in rice-fields.

Armigeres obturbans.—A few imagos of this mosquito were obtained in houses. Their breeding places were not discovered.

Lutzia vorax.—The larvae of this species invariably occurred in some abundance in cesspits, though only when the contents were so thoroughly decomposed that algal growth had become possible. In such pits the larvae of *C. fatigans* were far less abundant than elsewhere, the reason for which became apparent when about a dozen larvae of the *Lutzia* were collected into a bottle. They attacked each other with such ferocity that within an hour only two or three survived, and they fed freely on the larvae of *fatigans* on which a long series were bred to maturity. The pupae of this *Culex* however seemed to enjoy entire immunity from attack, possibly because at the surface they are not so readily seized by such assailants.

Anopheles hyrcanus.—The larvae occurred in great abundance in the rice-fields when at an advanced stage of cultivation, associated, as in Fuchow, with those of *C. tritaeniorhynchus*. As in Fuchow, thoroughly decomposed manure in a liquid state is poured on the fields, when they are first flooded ready for planting out the rice, but in Nagasaki a great abundance and variety of waste vegetable matter, such as cut grass, potato haulms, turnip tops, etc., are also thrown in and allowed to decompose before cultivation is commenced, the larvae being seemingly unaffected by the richness of the water in organic matter. In Nagasaki, as elsewhere in Japan, the larvae were similar in colour and pattern to those in the Chinese ports referred to.

Anopheles lindesayi.—Nine larvae, only, of this species were obtained, in clear chilly water bubbling up from a spring in the hillside, a habitat similar to that in which, as Dr. Hacker has written, he found them in India.

Anopheles punctibasis.—The larvae of this species were obtained in some abundance in the same muddy pool with those of *C. hayashi*. The insect has recently been described by Mr. F. W. Edwards (Bull. Ent. Res. xii. pt. 3, p. 274, Nov. 1921).

Kobe.

Kobe, situated in latitude 34° 41' North and longitude 135° 11' East on the Inland Sea of Japan, has recently superseded Yokohama as the principal port, the tonnage of vessels arriving and clearing amounting in 1919 to 36,100,000, for it is accessible to the largest steamers. The town is situated on a strip of land from a

half to one mile wide, between hills at the back and the sea, and so has a very long sea frontage. The population in 1919 was 588,124, and the town is distant only 20 miles from Osaka, also on the coast, with a population of 1,400,000. There is ample communication between the towns by steamers, trains and electric trams.

Trade.—The main trade of the Empire centres in Kobe, steamers from all quarters of the globe berthing there, after having, as a rule, first visited either Nagasaki or Yokohama.

Temperature and Rainfall.—These are practically those of Yokohama.

Water Supply.—A piped supply is everywhere laid on from reservoirs in the mountains at the back of the town.

Mosquitos.—The following species were obtained: *S. albopicta*, *A. (Finlaya) togoi*, *A. (Finlaya) japonicus*, *C. tritaeniorhynchus*, *C. fatigans* and *A. hyrcanus*, the larvae occurring in places similar to those in which they were found in Nagasaki. A species regarded by Mr. F. W. Edwards as *C. pipiens*, L., though the male genitalia are not quite identical with those of European specimens, was here obtained for the first time, breeding in similar places to *C. fatigans*, if not mixed with it.

There seemed also to be a marked reduction in *A. japonicus*, for one specimen only was obtained, though *A. togoi* occurred in great abundance.

Yokohama.

Yokohama is situated in latitude 36° 26' North and longitude 139° 38' East on Tokyo Bay, 18 miles south-west of Tokyo. It stands on a plain shut in by hills on either side. It is the sixth largest city in the Empire, with a population of 400,000 Japanese and 10,000 foreigners, who mostly reside in one quarter of the city.

Trade.—Its natural excellence as a harbour has made it one of the two greatest ports in the country, its imports and exports being second only to those of Kobe. All the steamer lines from China, India and Europe converge at Yokohama, and it is the first port of call for Trans-Pacific liners from the United States and Canada. It is in direct communication with ports of the west coast of Mexico and Central America, the ships of one of the large passenger lines, coming by way of the Panama Canal, taking from 23 to 27 days in making the journey from Panama to Yokohama, putting in at San Francisco *en route*.

Temperature and Rainfall.—The seasons correspond to our own, the mean temperature in the spring (March to May) being 55° F., in the summer (June to August) 73·9°, in the autumn (September to November) 60·6°, and in the winter (December to February) 39°. The cold in winter is often severely felt owing to northerly winds. The rainfall is about 70 inches annually. There is a heavy rainfall during the winter and early spring months, and after an intermission of a couple of months, mild rains fall with some constancy in June. The latter rains, coming at a season when with rising temperature mosquito activity begins to be felt, serve to keep possible breeding places constantly full of water, a factor of importance as favouring at that season the increase of mosquitos. At Kobe, and in the south, these rains are less constant.

Water Supply.—A piped supply serves the whole city, but the collection of rain-water in unscreened vats and barrels is general, there being a demand for it for the dyeing of cloth.

Mosquitos.—The following were obtained: *Stegomyia albopicta*, *Aedes (Finlaya) togoi*, *Culex pipiens*, *C. orientalis*, Edw., and *Anopheles hyrcanus*.

Stegomyia albopicta.—The breeding places of this species were of the same type as in Nagasaki, though the larvae were obtained less freely than in the south. They

were found, for example, in a hollow tree in one of the main streets, but were especially abundant in the cemetery of the Foreign Settlement, where plentiful breeding places were provided for them in the jam-jars, pickle-bottles, and similar inexpensive receptacles that had once contained those floral tributes, which, in accordance with pious custom, are at lengthening intervals placed upon the graves—until the decay of interest in the departed gives the female mosquito the reversion. The specimens here obtained were so diminutive as to make their recognition, which is usually so easy by reason of the very characteristic markings, difficult without the aid of a lens. Specimens taken in Fuchow and Shanghai were rather larger, but did not come up to the size of those ordinarily taken in the Malay States. The gradual diminution in size may well be due to conditions becoming more unfavourable to the species further north, for it was found repeatedly in the Malay States that poorness of the food supply resulted in the production of dwarfed imagos. The ability to attain maturity at all under such conditions is doubtless one of the reasons why this species and *S. fasciata* are so widely spread. All attempts to obtain in the Malay States dwarfed Anophelines by semi-starvation or by rearing them in unsuitable media failed: the larvae either attained a maximum growth and in due course afforded imagos, or else perished after a prolonged period of larval existence.

Aedes (Finlaya) togoi.—This species was found in the various types of breeding places already alluded to. It was especially abundant in certain quarters in butts of rain-water, and large numbers were obtained in the yards of stonemasons, in the cavities of various granite receptacles, such as mortars, bowls and troughs of all sorts, shapes and sizes, ornamental vases, etc. At a particular temple, at the main doorway, the pillars on either side rested in huge iron tubs, holding gallons of water. Examination for larvae in one of these, in which there were three golden carp, was negative; in the other, in which there were no fish, larvae swarmed. It had already been remarked that in none of the little ornamental ponds, invariably found in gardens of any size, were larvae found when goldfish were present. It was quite usual to find a few of these fish in surface wells and barrels of water, in which, again, no larvae were ever obtainable. While these larvae were invariably found in open situations, their near relation, *S. albopicta*, was found breeding, with very few exceptions, in thoroughly sheltered spots. The larvae of *Aedes japonicus* were not obtained here at all.

Culex orientalis.—The larvae of this species were found associated with those of *Anopheles hyrcanus*, having seemingly replaced those of *C. tritaeniorhynchus*, which were abundant in the south.

Culex pipiens.—This again had entirely replaced *C. fatigans*, and was found breeding in great abundance in similar drains and ditches.

Anopheles hyrcanus.—This was found in abundance, breeding, as usual, in rice-fields.

Conclusions.

Confirmation of the opinion expressed by Dr. Stanton in his report that "a survey of the ports of China and Japan would show that the conditions are unfavourable for the propagation of *Stegomyia fasciata*, even in the warmer months" was, therefore, obtained in regard to the places visited. In view of a record (Theobald, Monograph of the Culicidae, i, 1901, p. 293) of the capture of a single specimen of the insect in Tokyo (C. H. B. Wood, 3.viii.1899), a three-days' search for it was made in the suburbs there, especially on the seaward side. None were obtained, so that one may well conclude that, whatever the history of this particular specimen, the species has failed to establish itself there. There are recent records, however, of its presence in Kowloon, in latitude 22° 12' North on the mainland opposite Hong Kong, though sparingly in the latter place (*Stegomyia* Survey in Hong Kong, Bull. Ent. Res., vi, 1915, p. 67), and in Formosa (Secrete, 1917, "Notes of Mosquitos of Formosa.")

Abstract in China Med. Journal, Shanghai) in latitude $23^{\circ} 5'$ North, and so occasional specimens may find their way north, though as a factor in the spread of yellow fever, they would appear to be negligible.

The possibility of the establishment of yellow fever in the ports visited would seem to hinge on the potentiality of *Stegomyia albopicta*, and possibly other very near relatives, such as *Aedes togoi* and *A. japonicus*, to act as carriers of the disease. Mr. Kilner stated that in Shanghai these mosquitos are not seen during the colder months of the year, and this probably holds good of Fuchow, where bitter cold is also experienced. In Japan, which feels the benefit of the North Equatorial Ocean current, the seasons, especially in Nagasaki, are milder, and it would seem probable that here, with a mid-winter temperature no lower than $43^{\circ} 5'$, imagos may be active all the year round.

The work was greatly facilitated in Fuchow by the kind and ready help of Dr. Cheah and of Mr. H. S. Brand, the Secretary of the local Chamber of Commerce. I must acknowledge, further, the assistance received in Shanghai from Dr. C. N. Davis, the Acting Director of the Department of Public Health, and from Mr. E. Kilner, Chief Sanitary Inspector, and express my indebtedness to Mr. F. W. Edwards for the determinations of the mosquitos obtained.

NOTES ON THE SPECIES OF THE GENUS *MUSCA*, LINNAEUS—PART I.

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Of the many insects which we now know to be dangerous menaces to the health of man, the house-fly, *Musca domestica*, has few (if any) equals, but the facts relating to its germ-transmitting capacity are unfortunately still very incomplete. In the case of those Anopheline mosquitos which transmit the parasites of malaria, and the tsetse-flies, which infect man and other animals with trypanosomes, we are in a position to estimate the inefficiency and loss of life directly attributable to them, for in each case we know most of the species directly responsible for the dissemination of these parasites. But in the case of the house-fly we have no conclusive proof that *Bacillus typhosus*; for instance, is carried by one, or more than one, species of *Musca*. Further, by the time the cases are diagnosed, the infected flies have either died or disappeared, and it is rarely possible to trace the infection to them. It is true, however, that many observers have recorded the finding of pathogenic bacteria in, and on, species of *Musca*, but the final proof of the identity of these bacteria has invariably been faulty. Yet in spite of these discrepancies there is no doubt, from everyday practical observation the world over, that one, and more than one, species of *Musca* regularly carry the bacilli of the enteric fever, cholera and dysentery groups, as well as many other pathogenic organisms, especially the virus of trachoma, from infected material and deposit them on food and the human body. In investigating outbreaks of infectious diseases the house-fly should always be considered as a possible vector of the causal organisms.

The fact that the *CULICIDAE* contain among their members many serious pests has led to an intensive study of the species of the world, resulting in numerous valuable monographs and papers describing the species, and every medical man is now able to determine with certainty almost any species for himself. So also in the case of the tsetse-flies we have Austen's complete handbook available for the determination of the species; and similarly with many other insect pests. This systematic work on these important insects is very necessary, for it facilitates further biological studies, and, more particularly, accurate information on their relation to disease-causing germs.

But when we come to consider the all-important house-fly, *Musca domestica* and its allies, we find that although there are many valuable papers and books dealing with this species from the disease standpoint, there is no systematic work of any value which would enable the sanitary officer in the tropics to determine with accuracy the species which may call for enquiry during the course of his work. He cannot help but call all the species of *Musca* by the specific name *domestica*, for he believes that a house-fly with a striped thorax is *Musca domestica* all the world over. And there is every reason that he should do so, for in such an authoritative work as that on "The House Fly, *Musca domestica*, L." by the late Dr. Gordon Hewitt, we have a definite statement that the house-fly found throughout the world, and especially in tropical countries, is *Musca domestica*, L., and this statement has been accepted and copied by all subsequent writers on the subject. I propose to question it. That both the sexes of one of the species of *Musca* found in the tropics are very similar to *Musca domestica* is quite true, but when we come to compare the male with the male

of *domestica*, we find that the front of the former is at least half as wide as that of the latter. Were this only the case in a few specimens, I should be prepared to accept Dr. Hewitt's statement regarding the world-wide distribution of *Musca domestica*, but after examining hundreds of specimens of males of this tropical species, and comparing them with typical males of *domestica* caught in Great Britain, which I assume are conspecific with the Linnaean species, I find that in not a single specimen from India which I have examined is the front as wide as that of the male *domestica*. It is true that the width of the front of this form varies to a small extent, and so does that of the typical male *domestica*, but on the one hand I have yet to see a specimen of *domestica* from Great Britain with a front as narrow as that of this tropical form, and on the other hand a specimen of this tropical form with a front as wide as that of the typical *domestica*.

I am quite prepared to find a typical male of *domestica* taken at any of the tropical ports visited by ships from Europe, for everyone who has travelled in the East knows that large numbers of *domestica* are regularly carried to such ports, and leave the ships on their arrival at their destinations. In this way it is possible *Musca domestica* has been carried to the ports of the world, and has now become established there. But I must admit that the examination of the specimens in the National collection from the localities mentioned by Dr. Hewitt have not convinced me that this is the case.

It is true that Major Austen and other authorities have drawn attention to this narrow-fronted male house-fly and have determined it as *domestica*, L. But when we find a form exhibiting a character which is constant, I think we are justified in regarding it as distinct. And the width of the front in the males of the species of this genus is a constant character, and one of the most reliable for purposes of determination. In using this character it is very necessary to point out that great care must be taken in noting whether the front has collapsed, which it often does in the case of specimens pinned too soon after hatching and before the chitin has hardened. It should be remembered that just below the front there is an opening through which the ptilinum is protruded and later invaginated. If the insect is pinned before the edges of the ptilinal opening have sufficiently hardened, the whole front is very apt to collapse inwards; it then appears to be very much narrower than it really is, and it is only when such a specimen is macerated in caustic potash that the exact width of the front can be determined with accuracy. Further it is important to note that in comparing the front of one specimen with another it is very necessary to take into account their relative sizes. It is always better to compare the width of the front with the entire width of the head, or with that of one eye, rather than give it in linear measurement.

It may be thought that the question regarding the true identity of this tropical and subtropical house-fly is only of academic interest, and not worth further investigation, but I may point out that the biological connection of particular species of insects with certain disease-causing bacteria is now regarded as of a much more specific nature than has been thought to be the case hitherto. As a good example, I may draw attention to the case of the tropical rat-flea, *Xenopsylla cheopis*, which is the invertebrate host of *Bacillus pestis*. Until recently it was thought that there was only one species of the genus *Xenopsylla* found on rats in India, but a more careful study of rat-fleas has enabled Mr. Charles Rothschild to separate the Indian *cheopis* into three distinct species, one of which, *X. astia*, has undoubtedly been confused with *cheopis* in the past. It is thought by Cragg and Hurst that the absence of plague in certain areas is due to the larger percentage of *astia* found on rats as compared with the numbers of *cheopis*. If this is the case, then we have a clear indication that *astia* is not a good host for the extracorporeal life of *Bacillus pestis*. In the same way there may be a much more intimate connection between certain disease-causing bacteria and a particular species of *Musca* rather than with the others

which may feed side by side with it. For these reasons, then, I consider it is important to determine the true identity of this tropical house-fly. But in order to settle this question beyond any further doubt, it will be necessary to examine and compare the external genitalia of both sexes with that of *Musca domestica*, and to do this a large number of specimens from many parts of the world will be required, and this is one of the reasons I have raised this point, in the hope that this material will be collected. I have already begun the study of the external genitalia of the Indian species in order to compare it with that of *domestica*.

But the genus *Musca* contains another important group of species which have a direct bearing on the health of valuable stock animals, and which have in the past been confused with *Musca domestica*. The species I refer to, largely if not entirely, feed on blood and serous and pustular discharges, and are exclusively outdoor insects. Anyone who has watched a milch cow being tormented by hundreds of specimens of *Musca autumnalis* can hardly doubt that, apart from the possibility of their carrying disease germs, they must reduce the milk-producing capacity of the animal simply through wearing it out, as it constantly tries to drive them away. That flies do in this way so worry a cow as very materially to reduce the quantity of milk it produces, has been proved beyond any doubt by observers in America. These species of *Musca* regularly follow the true biting flies, sucking up any remains of blood that exudes when the latter withdraw their proboscides. They also regularly feed on the discharge from sores, cuts, eyes and the nose. We know nothing of the germ-carrying capacity of these species, and until all have been systematically studied, and veterinary officers and others are able to recognise them, we never shall.

During the last 15 years I have almost continuously studied all the stages of many of the species of this genus, and observed their habits in the field, for I am a strong believer in combining systematic studies with field observations. I have no doubt whatever that such field work gives one a much truer picture of the individual species than mere microscopic study of the dried insect. Field observations, in conjunction with studies of the breeding habits and the larvae, as well as microscopic studies of the adults, are the only means that I know of for coming to a final conclusion regarding some of the species of this genus. But as an isolated observer in the tropics, without access to the scattered literature on the subject, I have been severely handicapped in my systematic studies of the species. I have in the first instance had to depend on others for determinations of the species, and also on the inaccurate references to them in the general literature of the subject. As a result many errors have crept into my papers, and for the benefit of those who may use them I will draw attention to them in these notes.

Recently I had the first opportunity of studying the specimens in the National Collection at the British Museum, comparing them with the Indian species, studying many types, and lastly of consulting the complete literature on the subject. And I would like to take this opportunity of thanking Major E. E. Austen, D.S.O., for all the facilities and help he gave me. I have no hesitation in saying that were it not for his extensive knowledge of the subject, which he freely placed at my disposal, I could never have done as much as I was able to in the short time available. My own collection, together with the splendidly arranged and rich National Collection, has enabled me to unravel almost all the important synonymy. I have critically examined all Walker's types, as well as Bigot's, which Mr. Collin kindly lent me for the purpose, and for which I wish to take this opportunity of thanking him. Although I fully realise that much has yet to be worked out before it will be possible to be certain of the true identity of some of the species of the older writers, I consider that my study of this extensive material is sufficiently important to call for immediate publication.

But my main reason for publishing these notes is to draw the attention of medical and veterinary officers, and others, to the importance of collecting more material, for in spite of the many thousands of specimens which I have examined, I have no hesitation in saying that my revision of the genus will not be as complete as I should like it to be. I would, therefore, earnestly appeal to all who have opportunities of collecting species of *Musca* to send them to me at the Zoological Department, Edinburgh University, or to Dr. Guy A. K. Marshall, C.M.G., Director, Imperial Bureau of Entomology, British Museum (Natural History), Cromwell Road, when sending other entomological material; I shall be glad to exchange any Indian species for others.

As many of the types of the older writers, such as those of Robineau-Desvoidy and Macquart, are either lost or in very bad preservation, it is most important to try to secure specimens from the localities from which their types were obtained, and the localities will be mentioned in these notes. In order to facilitate the collection of this material, it may be useful to give some notes on the species as a whole, and also to indicate the special lines along which the collecting should be carried out.

For practical purposes, the species of the genus *Musca* fall into two natural groups as follows: (1) The house-fly group, and (2) the wild species group.

(1) *The House-fly Group.*

In this group are included all those species which are cosmopolitan in habit, but are mainly found in and around human dwellings, on food in bazaars, about butcheries, offal, rubbish of all kinds and night-soil trenches. The four important species are *Musca domestica*, *Musca domestica* (atypical), *Musca nebulosa* and *Musca humilis*. The first is the common European house-fly and the type of the genus, and *M. domestica* (atypical), *M. nebulosa* and *M. humilis* are the important tropical and subtropical species. Specimens of this type of house-fly are urgently wanted from as many localities as possible. *Musca humilis* is a very characteristically marked species, and can be easily recognised; but when we come to *Musca domestica* (atypical) and *Musca nebulosa* it is not possible at present to give a definite opinion regarding them. A series of specimens from the different ports as well as specimens from inland towns must first be available for microscopic study. Specimens taken *in copula* would be most useful. Larvae and flies hatched from them are the best material for comparative study. If the observer has not the time to pin the specimens they will do equally well if they are placed in match-boxes without any cotton-wool. Such specimens are quite suitable for the study of the external genitalia.

In collecting these species it is important to note exactly where the specimens were caught, whether on food, indoors, or in bazaars; and in this connection it should be noted that this type of *Musca* may be seen on cattle and horses in company with specimens of those of the next group. There should be no difficulty in collecting the larvae of the house-fly in any locality. When mature they should be placed in some earth in a cigarette tin, the lid of which is perforated with small holes, and allowed to pupate. At the same time some specimens should be preserved by dropping them into boiling water in a test-tube, and then placing them in a tube containing 70-80 per cent. alcohol. As soon as those in the tin have pupated, the puparia should be collected and placed in dry tubes, and 36 hours after the flies have hatched out they should be pinned along with their puparia; the latter are most useful in correctly associating the larvae with their respective adults. A good series of males and females collected in this way would be most valuable for comparative study.

(2) *The Wild Species Group.*

Some years ago I drew attention to the peculiar habit of *Musca pattoni*, Austen, which feeds on the blood that exudes from the punctures made by biting flies, and on the serous fluid which exudes from cuts, sores and particularly from cowpox

vaccine scarifications, on the bellies of calves. Since then, in collaboration with Major Cragg, I.M.S., I have described several other Indian species that have a similar habit. Looked at with the naked eye, the species of this group closely resemble *Musca domestica*. I have never seen a single specimen of any of these species caught in the bazaars in India, and with the single exception of *Musca humilis*, they are found only on animals, sitting about on plants, and on cow-dung. They are all necessarily intermittent feeders, and flit about from one animal to another, never staying long at one spot; and herein lies their importance as the possible carriers of trypanosomes such as those which cause nagana and surra. I would, therefore, particularly like to draw the attention of veterinary officers practising in the tropics to these haematophagous species of the genus *Musca*. They abound in all tropical countries, and specimens can always be caught on animals, as well as on dead game.

All the Indian species I have studied breed in cow-dung, either when it is dropped in the fields, or when piled up in heaps around cowsheds, etc. The larvae of all the species in any given locality can be easily collected by scooping up patches of cow-dung about 24 hours old, and placing it on earth in a tin tray with sides up which the larvae cannot crawl. There is no need to disturb the dung, but the tray should be placed in the sun every day, and the earth at the sides of the tray regularly examined for pupating larvae. Such larvae are of a characteristic creamy white colour, and do not contain any food. They should be collected, some preserved as noted above, and the remainder allowed to pupate in earth in a cigarette tin. The puparia should be dealt with as noted above, always remembering to pin the puparium of each specimen under it. The mature larvae of most of the species leave the dung to pupate, but others may stay just under it, so that it is necessary towards the end of the observation to turn over the dung and examine it for puparia. The puparia of several of these species are almost white, while others are of a greyish colour.

THE ORIENTAL SPECIES.

In addition to the specimens from this region in the National Collection, I have re-examined my own extensive collection consisting of about 2,500 specimens, the majority of which have been bred from larvae, most of the species being represented by long series in perfect preservation. I am able then to note the variations in external characters, a point of considerable importance in determining an atypical specimen; and anyone who has examined many species of this genus will have noted the great difficulty often experienced in giving a name to an odd specimen which is in some respects atypical, or greasy. I also have a long series of bazaar flies collected from all the larger towns in North India.

In these notes I propose recording my preliminary studies of the Oriental species, but it should be understood that as more material becomes available for macroscopic and microscopic study, it may be necessary to revise any previous conclusion, so that these notes must not be considered to represent the final revision of the Oriental species, but rather a preliminary contribution in that direction. In collaboration with Mr. Senior-White, I am now preparing a paper in which all the Oriental species will be described and illustrated; we hope to be able to include in it a simple yet accurate key for the determination of these species.

1. *Musca nebulosa*, Fabricius.

Synonyms: *Musca determinata*, Walker.

? *Musca multispina*, Awati.

In 1910, Major Austen determined the common Madras house-fly for me as *Musca nebulosa*, and since then I have always referred to this species under that name. Fabricius, in his short and wholly inadequate description of this species, states that the type, a female, is from "India Orientalis," and was given him by Professor

P. C. Abildgaard. In order to discover the exact locality from which the type was obtained, Major Austen kindly searched the literature to see whether this Professor P. C. Abildgaard was ever in India, but beyond the fact that he was a Veterinary Surgeon, and interested in natural history, there is nothing to show whether he had travelled in India. The exact locality from which the type of *Musca nebulo* came must then, in the meantime, remain doubtful. I think, however, that it can be safely assumed that it was obtained from some large Indian town. Wiedemann, who evidently examined the type, does not give any information on this point. His somewhat fuller description, however, fits this common Indian house-fly very well. Short of examining the type I see no reason to doubt Major Austen's determination of its identity, and consider it is best to retain this name for it.

I have carefully, and repeatedly, examined the type of Walker's *determinata*, a female in bad preservation, from the East Indies (not the West Indies as erroneously stated in my paper on the Mesopotamian house-flies), and after comparing it with typical specimens of the Madras house-fly (*M. nebulo*), have come to the conclusion that it is identical with it. There seems to be no means of discovering from what part of India the type of *determinata* was obtained, but the town of Calcutta seems to be the most probable locality. In my paper on the Mesopotamian house-flies referred to above, the species there described as *Musca determinata*, Walker, is not conspecific with Walker's type, but is the next species recorded in these notes.

Although I have not had an opportunity of examining the type of Awati's *Musca multispina*, I have little doubt from his description of the female that it is *Musca nebulo*.

I have examined many hundreds of specimens of *nebulo* from many localities in India, Burma, Assam and Ceylon, and find that though it varies to some extent in colour and markings, it is a very distinct species and cannot be confused with either *Musca domestica* or *Musca domestica* (atypical) noted below. The majority of the specimens when in good preservation have white cheeks, a grey thorax and yellowish abdomen, with silvery tessellation. In the male the frons is narrow, about as broad as the width of the third antennal segment (antero-posteriorly), and although in some specimens it is a trifle narrower, and in others a little wider, I have not seen a single specimen whose frons in any way approaches the width of the frons of the male *Musca domestica*.

I shall be glad to receive any specimens of this species from any area outside India, so as to compare them with those found in various parts of India.

2. *Musca domestica*, L. (atypical).

Synonyms: *Musca biseta*, Hough.

Musca divaricata, Awati.

Musca determinata, Patton (*nec* Walker).

This species, which for the lack of a better name I propose in the meantime calling *Musca domestica* (atypical), is the one which comes very near the true European *Musca domestica*, so far as external characters are concerned; it is one of the other important house-flies of India. Both sexes have been described by Awati under the name *divaricata*, and this observer points out that it closely resembles *nebulo* (*multispina*, Awati), but can be distinguished by noting that it is a much yellower fly than *nebulo*, and the abdomen is not nearly so silvery. The frons of the male of this species is about as wide as that of the male *nebulo*, and is from a quarter to one-fifth the width of the eye. I have not seen a single specimen of the male of this species with a frons as wide as in the male of *domestica*. I consider it is therefore distinct on this character alone. It is, however, not possible at present to give

it a name, and it will be necessary to compare the external genitalia of both sexes with those of *domestica*, L., as well as with those of specimens from other tropical countries. I believe the following will prove to be this atypical form of *domestica* :—

1. *Musca sanctae-helenae*, Macquart, Saint Helena.
2. *Musca lateralis*, Macquart, Mauritius.
3. *Musca basilaris*, Macquart, Brazil, Mexico.
4. *Musca frontalis*, Macquart, Algeria.
5. *Musca analis*, Macquart, Chili.
6. *Musca consanguinea*, Rondani, America, Mexico.
7. *Musca senegalensis*, Macquart, Senegal.
8. *Musca flavinervis*, Thomson, Ross's Island.
9. *Musca antiquissima*, Walker, Australia.
10. *Musca calleva*, Walker, South Africa.
11. *Musca vicaria*, Walker, New Zealand.

I have examined Bigot's types of *Musca pampasiana* (Buenos Ayres), *Musca flavifacies* (New Caledonia), and *Musca atrifrons* (Cuba), and consider that they are all specimens of this form. There seems very little hope of getting any further light on Macquart's species, as Mr. Collin tells me that his types are in bad preservation.

When examining these atypical forms of *domestica* in the National Collection, Major Austen drew my attention to its occurrence in Greece in company with the typical *domestica*, but exactly where this species first makes its appearance in the Palaearctic Region, I am not at present able to say. I hope those who have opportunities of examining and collecting specimens of *Musca* from Europe will be on the look-out for this narrow-fronted male *domestica*, and send me specimens.

I have no doubt that Hough's *Musca biseta* is this species ; it is common in Aden and most probably in Somaliland.

3. *Musca humilis*, Wiedemann.

Synonyms : *Musca primitiva*, Walker.
Musca conducens, Walker.
Musca praecox, Walker.
Musca angustifrons, Thomson.
Musca bivittata, Thomson.
Musca niveisquama, Thomson.
Musca eutaeniata, Bigot.
Musca promisca, Awati.

This strikingly marked species is the most important tropical house, bazaar and camp fly. It is of peculiar interest, as in its habits it links the house-fly with the wild haematophagous species. Its larvae may be found in a great variety of food-stuffs, in isolated patches of cow-dung, horse-dung and human excrement ; also in cow-dung and horse-dung when piled in heaps, in night-soil trenches, and in decaying vegetable matter. I have also bred it in dog's dung and in the decomposing bodies of rabbits. As it commonly breeds in patches of cow-dung when dropped in the field, the adults are frequently found on cattle and horses far from human dwellings. Under these conditions they feed on the discharge coming from sores, and from the eyes and noses of cattle. As often as not, the specimens which hatch out of larvae in isolated patches of cow-dung are very small, and they are most irritating pests in the fields, swarming about one's head, as do the adults of *Hydrotaea irritans* in the summer months in Europe.

In India it swarms in the bazaars, where it may be seen on food-stuffs of all kinds, as well as on human beings, particularly around the eyes of children. In Mesopotamia it was quite common to see the eyes of small children covered with the females of this species, and this explains how the eyes of adults become infected with various pathogenic bacteria.

Musca humilis is very widely distributed, probably more so than any other species of the genus. I have seen specimens from many parts of Africa, Palestine, Mesopotamia, Persia, and from the whole of India to China in the East.

The late Professor Stein examined Wiedemann's type of *humilis*, as well as Thomson's types of *angustifrons* and *bivittata*, and says all three are the same species. Until I can for myself examine these types I accept this determination.

I have examined Walker's type of *Musca conducens*, a male collected by Wallace at Macassar, Celebes; it is in good condition and is a small example of *M. humilis*. Walker's type of *M. præcox*, a headless male from Ceram, Malasia, is exactly similar, and is also a small specimen of *M. humilis*. Walker's type of *M. primitiva*, a female from Fu-chau-fu, South China, is a typical specimen of *M. humilis*.

Bigot's collection of *Musca*, fifty-three specimens, contains six males of his *Musca eutaeniata* from "the Indies," chiefly from Pondichery and Cochin China, all of which are rather small, but typical specimens of *M. humilis*. It will be remembered that Brauer examined these specimens,* and came to the conclusion that like eight of the other specimens of *Musca* in Bigot's collection (Brauer's numbers 257 to 265, inclusive) they were "*Musca ead.n.* (wie die ersten 9 wohl *domestica*)." It is quite clear from this that Brauer had a very vague knowledge of the species of the genus *Musca*, otherwise he would never have called these six specimens of *M. humilis* (*eutaeniata*), *domestica*. This is a warning not to accept the determination of types by others as final without oneself examining them. Stein states that *M. niveisquama*, Thomson, is identical with *M. domestica*, L. Major Austen has, however, drawn my attention to Thomson's description of this species, in which he clearly states that *niveisquama* is similar to his *angustifrons*, and has two black thoracic stripes. It is quite possible that *niveisquama* is *Musca pumila*, Macquart.

Awati gives *angustifrons* as a synonym for his *Musca promisca*, and his description of this species makes it quite clear that it is *M. humilis*. This author, when describing the three species, *Musca nebulo* (*multispina*), *M. domestica* atypical (*divaricata*), and *M. humilis* (*promisca*), states that in the case of *nebulo* there are "two or more spines on the humeral vein which may be present on both wings or on one of them only;" in the case of *M. domestica* atypical (*divaricata*), he says there is "only one spine on the humeral vein," and in *M. humilis* also only one spine on this vein. In his remarks at the end of the description of *M. divaricata* he says: "There are always more than one spine on the humeral vein in *Musca multispina*, whereas in *Musca divaricata* there are never more than one." By the humeral vein Awati evidently refers to the large basal root vein from which arise the subcostal and radial (subcostal; 1st longitudinal) veins just before the small humeral transverse vein joins this root vein to the costal. In all the species of *Musca* which I have examined, there are always one or more small curved bristles situated on the inner side of the vein. I have made a careful examination of the number of bristles present on the veins of hundreds of specimens of *Musca nebulo*, *M. domestica* (atypical) and *M. humilis*, and in a long series of *domestica* (atypical) in the National Collection a large percentage had two bristles on the right root vein, and only one on the left; a few, on the other hand, had two on the left vein and only one on the right. The majority, however, had only one bristle on each vein. In the case of a long series of *nebulo*, I find that a few have two bristles on the left vein and one on the right, while some have two on the right and only one on the left. But, and this is important in view of Awati's statement that in this species there are always two bristles on this root vein on both sides, I find that the majority of the specimens of *nebulo* only have one bristle on each root vein; this also applies to *humilis*.

Musca humilis can always be recognised by noting that it is a much greyer fly than the two others noted above; that in the female the black thoracic stripes are united behind the suture, forming one broad stripe, but are separated in front of the suture; in the male the stripes on each side have coalesced to form one broad

black stripe, which diverges posteriorly away from the central grey stripe; the abdomen in the female is quite unlike that of the male, and is yellowish grey with black stripes and bands; that of the male yellowish with silvery patches and a central black stripe. The frons of the female is wide, that of the male a little narrower than the frons of the male *nebulo*.

It would be interesting to know if this species has found its way to any part of the New World.

4. **Musca sp. incerta** ("Textbook of Medical Entomology," Patton and Cragg, p. 334).

This distinct species was bred in 1910 from larvae collected from the contents of the stomach and intestines of sheep slaughtered at the slaughter-house, Saidapet, Madras, and since then another good series has been obtained from the same source; it also breeds in horse-dung. It will be described as a new species in a forthcoming paper on some new Indian species of the genus *Musca*.

On a superficial examination it may be mistaken for *Musca nebulo*, but it will be noted that the ground-colour of the thorax is darker and is of a bluish colour. It has four black thoracic stripes, and the male frons is much narrower than that of the male *nebulo*, the eyes being separated only by a fine black line. The abdomen in both sexes is much more orange-coloured, and in the male there are no marginal silvery patches on the apparent second segment; in the male *nebulo* these silvery patches are always well marked.

5. **Musca pumila**, Macquart.

Synonyms: *Musca minor*, Macquart.

Musca vetustissima, Walker.

Musca humilis, Stein (*nec* Wiedemann).

Musca corvina, Froggatt (*nec* Fabricius).

I first bred this species from larvae collected from human excrement in 1910 in Madras, and in 1920 obtained a large number from the same source. Mr. Senior-White has collected it in Ceylon. I have received a number of specimens from Australia, sent me by Mr. Taylor, Mr. Froggatt, Mr. Hill and Dr. Ferguson, and all are identical with the species in the National Collection determined by Major Austen as *Musca pumila*. There is also a specimen in Bigot's collection from Australia labelled *Musca pumila*, Macquart. As it is superficially like *M. humilis* it has been mistaken for that species. In both sexes the thoracic markings are exactly similar to those of *M. humilis*, but the ground-colour of the thorax is markedly blue, whereas in *humilis* it is yellowish grey. The abdomen in the female is also bluish, with black stripes and bands. So far I have not seen the typical *Musca humilis* from Australia, and *Musca pumila* seems to take its place.

6. **Musca ventrosa**, Wiedemann.

Synonyms: *Musca xanthomela*, Walker.

Musca pungoana, Karsch.

Musca nigrithorax, Stein.

Musca kasauliensis, Awati.

Musca hilli, Johnson & Bancroft.

This small species, with its dark thorax with four stripes and orange-yellow abdomen, is a true haematophagous *Musca*, and is mainly seen on animals, and on foliage near them. Wiedemann's types of *ventrosa* came from Sumatra and China. I have examined the type, a female, of Walker's *Musca xanthomela* from Macassar, Celebes, and find it is a typical specimen of *ventrosa*; Stein's *nigrithorax* from Samarang and Batavia, and Karsch's *Musca pungoana* from Pungo Ndongo, Portuguese West Africa, are also this species.

I have examined the paratypes of *Musca hilli*, Johnson & Bancroft, and except for some dark markings on the apparent second and third abdominal segments, they are identical with the Indian specimens of *ventrosa*, in many of which there are also some dark markings on the same segments. I can see no reason at present for considering *M. hilli* to be a distinct species, but hope to compare the external genitalia of the Australian and Indian specimens to settle its identity.

Awati gives his *Musca kasauliensis* as a synonym of *M. nigrithorax*, and there seems to be no doubt that his species is *M. ventrosa*.

Musca ventrosa is widely distributed in India, Burma, Assam and Ceylon, and is also common in Africa; it breeds in cow-dung.

7. *Musca albomaculata*, Macquart.

Synonyms: *Musca dorsomaculata*, Macquart.

Musca convexifrons, auctores (*nec* Thomson).

Musca setigera, Awati.

This species was determined for me by Professor Bezzi as *Musca convexifrons*, Thomson. It is one of the common haematophagous species, and has been fully described in collaboration with Major Cragg, I.M.S. On comparing Thomson's description of *convexifrons* with it I have come to the conclusion that the Indian species long known under this name is not Thomson's species. The discrepancies are as follows: Thomson says that his specimen, a male from China, measures 6 mm., but the largest Indian specimens I have seen measure only 5.5 mm.; and further, he says that his species is like *Musca autumnalis*, de Geer (*corvina*, F.), which is quite unlike the Indian species. In order to settle this point I recently sent a typical male to Professor Sjöstedt for comparison with Thomson's type, and Dr. Roman has kindly given me a note as the result of his examination and comparison of the two species; from this it is quite clear that the Indian species is not *Musca convexifrons*. Dr. Villeneuve tells me that he has compared this Indian *Musca* with Macquart's types of *Musca albomaculata* and *M. dorsomaculata* and finds they are identical. I accept this determination for the present. I have very little doubt that Thomson's *convexifrons* is the species known as *Musca fergusoni*, Johnson & Bancroft (*australis*, Macquart, *nec* Boisdual), a species which is widely distributed in Australia, as well as in the many neighbouring islands, and presumably extends to China. At any rate, this species is very like *Musca autumnalis*, de Geer. If this should eventually prove to be the case, the Australian species must in future be known as *Musca convexifrons*, Thomson.

8. *Musca pattoni*, Austen.

Synonym: *Musca spinosa*, Awati.

This species has been fully described by Austen, and the types are in the National Collection. It is widely distributed in India, Burma, Assam and Ceylon, but I have not seen any specimens from any locality outside India. Awati has described the female under the name of *Musca spinosa*.

9. *Musca gibsoni*, Patton & Cragg.

Synonym: *Musca latiparafrons*, Awati.

This species was described by me in collaboration with Major Cragg, I.M.S. It is especially abundant in hill stations on animals. The female has been described by Awati under the name *Musca latiparafrons*.

10. *Musca spinohumera*, Awati.

The female of this larviparous species has been fully described by Awati. Mr. Senior-White recently collected a large number on cattle at Pusa and noted that it is haematophagous in habit. He also observed that it deposited one larva at a time, thus confirming Awati's observations; the puparium is very like that of *Musca pattoni*, and is of a dirty white colour.

I have examined this collection, which also contains the male, and compared both sexes with those of *M. pattoni* and with the types of *M. mesopotamiensis*, Patton. Though *M. spinohumera* superficially resembles *M. pattoni*, they are quite distinct, the one being oviparous and the other larviparous. *Musca spinohumera* is, however, closely related to *M. mesopotamiensis*, but there are some good characters by which they can be distinguished, and here again one is oviparous and the other larviparous. I have not seen *M. spinohumera* from South India, and it appears to be peculiar to Northern India.

Awati mentions *M. corvina*, Fabricius, as a synonym of his *spinohumera*, evidently meaning the form which the late Professor Portchinsky referred to as *Musca corvina*, Fabricius (*vivipara*). It will be remembered that Portchinsky pointed out that there were two types of *M. corvina* in Russia, one which he called *M. corvina ovipara*, found in Northern Russia, which lays stalked eggs and has a white puparium, and the other, *M. corvina vivipara*, which deposits larvae and has a brown puparium, and is only found in the Crimea. In the paper on "Certain haematophagous species of the Genus *Musca*" (Ind. J. Med. Res., i, no. 1, 1913), in collaboration with Major Cragg, I.M.S., attention was drawn to the observations of Portchinsky in a footnote on page 12, and after examining a good series of both forms, it was concluded that they were distinct species. To quote our words, "From our knowledge of the oviparous *convexifrons* (spined eggs and white puparium), *pattoni* (spined eggs and dirty grey puparium), and the larviparous *bezzii*, it appears to us that Portchinsky has confused two distinct species of *Musca*, one entirely oviparous and the other entirely larviparous." Since then I have studied all the stages of the oviparous species now known as *Musca autumnalis*, de Geer, in the South of England, and observed that it lays its stalked eggs singly in patches of fresh cow-dung dropped in the field, and that the puparium is white. But with regard to the larviparous species, Major Austen has drawn my attention to the curious fact that there is no description of it in any of Portchinsky's writings, and yet I find that Schnabl and Dziedzicki in their work, "Die Anthomyiden," speak of it as *Musca larvipara*, Portchinsky (*olim Musca corvinoides*, in litt. Schnabl & Dziedzicki). As they partly describe the male, the species must in future be known as *Musca larvipara*, Schnabl & Dziedzicki, and not Portchinsky.

As my material of this species is old and not in good preservation, I shall be glad to exchange any Indian species for fresh material.

11. *Musca bezzii*, Patton & Cragg.

Synonym: *Musca pilosa*, Awati.

This large handsome fly is very common in all the Indian hill stations, and also at the foot of the hills. It is purely haematophagous in habit, and is only found on and around animals. The female deposits one larva at a time, in the second stage, on patches of fresh cow-dung.

M. bezzii belongs to the *lusoria* group, but is distinct from that species. The male has a dark thorax and yellowish abdomen, with silvery patches and stripes. The female is greyish, with black bands and stripes.

12. **Musca (Pristirhynchomyia ; Philaematomyia) lineata**, Brunetti.

This small haematophagous species is widely distributed in India, and is always found on and near cattle in the fields. It is not a true blood-sucker in the sense that it can draw blood, but it has moderately well-developed prestomal teeth, and can certainly scratch a clot off the skin and suck up any fluid under it. It thus shows an early change towards the true scratching proboscis, so well seen in the case of *Musca crassirostris*, Stein, which is able to draw blood with the aid of its prestomal teeth.

It will be remembered that in the typical *lineata*, the rather narrow thoracic stripes are distinctly separated, whereas in what appears to be a variety which I bred in Coonoor from cow-dung, and which Mr. Senior-White has also bred from the same source in Ceylon, the thoracic stripes are distinctly broader, and in the male almost, if not entirely, coalescent behind the suture; in addition, the front of the males of this variety is much narrower than in the typical *lineata*. I am not able to express a definite and final opinion as to the identity of this variety, but as I have the larvae of both the species, as well as a large number of adults, I hope to do so shortly. I may, however, point out that the male is quite easily mistaken for a small specimen of *Musca humilis*, but it is certainly not that species.

13. **Musca cingalaisina**, Bigot.

Synonyms: *Musca pollinosa*, Stein.

Musca (Philaematomyia) indica, Awati.

I have examined the type of Bigot's *cingalaisina*, a female without a head, from Ceylon, and have no hesitation in saying it is a typical specimen of *Musca indica*, Awati. I have examined hundreds of specimens of this most interesting species from many parts of South India and from Ceylon collected by Mr. Senior-White. It is extremely common in Ceylon, and though neither Mr. Senior-White nor I have ever caught it on cattle in the act of sucking blood, it is unquestionably a blood-sucker, and can draw blood with the aid of its prestomal teeth. Mr. Senior-White is now engaged in studying its feeding habits, which appear to be very peculiar. In localities where it occurs it can be caught in large numbers sitting about on leaves, etc., and on fresh cow-dung, on which it deposits its third-stage larva. It is very curious that although it can be seen on cow-dung close to a cow, it has never been seen either by Mr. Senior-White or myself actually on the animal. Awati also states he has not seen it sucking blood.

I have no doubt whatever that Stein's *pollinosa* is this species, and it appears to be common in Batavia, Samarang and Tandjong Priok, in the Dutch East Indies. Brauer came to the conclusion that the type of *cingalaisina* was a specimen of *Musca domestica*, a remarkable determination.

14. **Musca (Ptilolepis) inferior**, Stein.

Synonym: *Philaematomyia gurneyi*, Patton & Cragg.

In a recent paper Bezzi has made this species the type of a new genus, *Ptilolepis*, mainly basing it on the presence of dark hairs on the inner portions of the squamae. He also gives some additional characters, the majority of which, however, are in my opinion not generic characters, but are common to many of the other species of *Musca*. He mentions "Eyes bare, rather distant in the male. Parafrontal hairs of the female arranged in more than one row," and other characters based on chaetotaxy. The presence, absence and arrangement of bristles and hairs are not reliable characters on which to base genera. Further, I would point out that the characters of the proboscis, such as, "thickened basally with chitinous terminal teeth," are common

to several species, and that there are three bristles on the radial root vein and not one, as mentioned by Bezzi. It is true, as Bezzi points out, that the presence of long hairs on the posterior portion of the upper surface of the squamae is unique in this species, but I do not consider this to be of generic importance.

Musca inferior is a true blood-sucker and is widely distributed in India, but it is never seen in large numbers and is easily missed. It can always be recognised by noting that as soon as it settles on the skin of an animal it begins to suck blood at once, whereas *Musca bezzii*, which closely resembles it, flits about from one spot to another. I have one male specimen, which was caught on a patch of human excrement. It probably breeds in cow-dung and is almost certainly larviparous.

15. *Musca* (*Philaematomyia*) *crassirostris*, Stein.

Synonym : *Philaematomyia insignis*, Austen.

Musca crassirostris is one of the most important cattle pests in India, and it would be well to name it the "Cattle Fly." I have little doubt that it very materially reduces the quantity of milk of Indian milch cows, owing to its vicious biting habits and incredible numbers. I have repeatedly seen the legs of a cow covered with large numbers of this fly, and the animal then spends a great amount of its time driving them off. These animals are often forced to lie down and curl their legs under their bodies, in order to protect themselves from the attacks of *M. crassirostris*.

It is interesting to note that it lays a relatively large egg, which hatches out in a very short time, suggesting that some development has already commenced while the egg was still in the ovary.

It is widely distributed in the Oriental Region, and is also found in many parts of Africa, and I have little doubt that when it is more carefully looked for will be found in many other localities. I see no reason for placing this species in a distinct genus, *Philaematomyia*, on the structure of the proboscis alone, for I now know five species that have this type of proboscis, which are otherwise typical specimens of *Musca*.

In a paper that is now in preparation I hope to describe five new species of *Musca* from India (inclusive of No. 4 noted above), one of which has well-developed prestomal teeth. I have now received specimens of the typical *Musca domestica* from Kashmir, as well as *M. tempestiva*, Fallén, and *M. vitripennis*, Meigen, all collected by Dr. Bains Prashad; and including these, there are now 22 good species of the genus *Musca* found in India. So far, I have not seen a single specimen of *M. albina*, Wiedemann, from any part of India, although the type is said to have come from the East Indies. This species has been sent to me from Egypt, and Bezzi records it under the name *speculifera* from Djerba, Tunis. I have not seen any species which could be identified as *Musca minuta*, Awati, *M. negriabdomina*, Awati, or *M. striatecta*, Awati. I shall be very glad of any specimens of *Musca* from any locality in the Oriental Region, and hope that those who have opportunities of collecting these flies will do so and send them to me, so that the revision of this group may be satisfactorily completed.

THE AUSTRALASIAN SPECIES.

Although the National Collection is not very rich in material from the Australasian Region, it contains several types and paratypes, which have enabled me to settle the identity of some of the doubtful species. I have also been able to supplement this collection with a number of specimens of most of the species sent me from time to time by Mr. F. H. Taylor, Mr. W. W. Froggatt (Entomologist to the Government of New South Wales), Dr. Eustace W. Ferguson (Department of Public Health, Sydney), Professor T. Harvey Johnson, and Mr. G. F. Hill (Entomologist to the Australian

Institute of Tropical Medicine). Mr. Hill in particular recently sent me a valuable collection of MUSCIDAE from various localities. I wish to take this opportunity of thanking these gentlemen for the trouble they have taken in collecting and sending all these specimens.

The revision of the species from the Australasian Region has been most difficult, owing to the great confusion existing as to the correct names of even the commonest species; most, if not all, of these have been described by the older authors, but unfortunately their descriptions are for the most part valueless, if not actually misleading. It is for this reason that I would earnestly appeal to those who have opportunities of collecting species of *Musca*, to let me have as many specimens as possible. I would particularly like large numbers of house-flies from any part of the Region, either in 80 per cent. alcohol or packed in matchboxes. It will only be by comparing large numbers of specimens of the species from as many localities as possible with those from other regions, particularly the Oriental, that it will be possible to settle the true identity of the species of the older authors. And it would be most unfortunate if my final revision were to be incomplete merely for the want of sufficient material. Larvae and flies bred from them are the best material for the comparative studies I now have in hand.

1. *Musca domestica*, L. (typical).

Synonym: *Musca vicaria*, Walker.

Of the 58 specimens of this species in the National Collection from various parts of Australia, and from the Sandwich, Samoan, Solomon and Fiji Islands, I have provisionally determined 21 (including the type of Walker's *vicaria*, a female from New Zealand), as belonging to this species. And I have specimens in my own collection which are undoubtedly this species.

2. *Musca domestica*, L. (atypical).

Synonym: *Musca antiquissima*, Walker.

The remaining 36 specimens in the National Collection (including the type of Walker's *Musca antiquissima*, a male), belong to the form of *domestica* in which the male has a front much narrower than that of the typical form. Most of the specimens in my own collection conform to this type, so that it would appear that it is one of the common house-flies of Australia; its true identity will only be arrived at by examining microscopic preparations of the external genitalia of both sexes and comparing them with the similar form from other regions. I should be glad of some hundreds of specimens of this species.

3. *Musca pumila*, Macquart.

Synonyms: *Musca minor*, Macquart.

Musca vetustissima, Walker.

Musca autumnalis (*corvina*), Froggatt (*nec de Geer*).

Musca humilis, Stein, Bezzi (*nec Wiedemann*).

This species is identical with a *Musca* bred by me more than 10 years ago in Madras. It has been confused with *Musca humilis*, Wiedemann. It appears to be a troublesome bush fly in Australia, and I have four small females sent me by Mr. Froggatt with a note that they were caught in tents. There are three specimens, one male and two females, in the National Collection from Cloncurry, Queensland, collected by Dr. Priestly, who notes that it is a troublesome fly, settling on the human eye and probably carrying the bacteria of eye diseases. In Australia it appears to have taken the place of *Musca humilis*. The Australian specimens differ slightly from the Indian in that the frontal stripe of the male is usually a little broader, but this is a variable character.

4. *Musca terrae-reginae*, Johnson & Bancroft.

I have seen only six specimens, five females and one male, of this species, sent me by Mr. Hill and Prof. Johnson, as well as the paratypes deposited in the National Collection by the latter. I am not able with this very meagre material to come to a definite conclusion regarding the true identity of this species. It will be impossible to discover what *Musca prisca*, Walker, really is, as the type (a female from New Zealand) is unfortunately a greasy specimen, and was evidently in this condition when Walker described it; it should never have been described. One thing is certain, it is a species with four black thoracic stripes and may quite well be *Musca terrae-reginae*. I hope to re-examine it more critically, and to compare it with *M. terrae-reginae*, but if this examination does not lead to any definite conclusion, I propose to drop this name altogether. More specimens of *M. terrae-reginae* are, however, required in order to compare it with some of the Indian species with which it is allied.

5. *Musca ventrosa*, Wiedemann.

Synonyms: *Musca xanthomela*, Walker.
Musca pungoana, Karsch.
Musca nigrithorax, Stein.
Musca kasauliensis, Awati.
Musca hilli, Johnson & Bancroft.

In my notes on the Oriental species I pointed out that I had examined the paratypes of *Musca hilli*, Johnson & Bancroft, deposited in the National Collection by Prof. Johnson, and considered it to be identical with *Musca ventrosa*, Wiedemann. Mr. Hill recently sent me a long series of *M. hilli*, and among them a couple which have been determined by Prof. Johnson, and though most of these specimens show varying amounts of dark stripes on the apparent third and fourth abdominal segments, they appear to be identical with Indian specimens of *M. ventrosa*. The final determination will depend on a comparative study of the external genitalia of both sexes, which I now have in hand. It may be that *Musca hilli* is a good species.

6. *Musca convexifrons*, Thomson.

Synonyms: *Musca australis*, Macquart (*nec* Boisduval).
Musca fergusonii, Johnson & Bancroft.
Musca lusoria, Bezzi (*nec* Wiedemann).

In my notes on the Oriental species I have pointed out that *Musca fergusonii*, Johnson & Bancroft, is the species known as *Musca convexifrons*, Thomson. It will be remembered that Thomson described as his type a male from China, and that for a long time it was believed to be identical with a common Oriental species, which is recorded above under the name of *Musca albomaculata*, Macquart. But I was convinced that the Oriental species was distinct from Thomson's *M. convexifrons*, and was for a long time puzzled as to the identity of Thomson's species. I now, however, have no doubt whatever that it is the common Australian haematophagous *Musca* recently re-described by Johnson and Bancroft under the name *Musca fergusonii*. Mr. Hill recently sent me a long series, some of which were collected on Palm and Magnetic Islands, and I have been able to compare it with *Musca lusoria*, Wiedemann, and *Musca bezzii*, Patton & Cragg. In *Musca convexifrons* there are normally two bristles on the basal portion of the radial vein, sometimes three; in *M. lusoria* there are normally four bristles, sometimes more and sometimes less; and in *M. bezzii* there are normally five. *M. convexifrons* differs in many other respects from both these species.

These six species of *Musca* represent all those known to me from the Australasian Region, but I have no doubt that there are several others which have yet to be discovered. It is to be regretted that I have no specimens of *Musca* from any part of New Zealand, and I trust that those who are interested in this important group of flies will send me material from this part of the region.

In my next series of notes I shall record my studies of the species of *Musca* from the Ethiopian Region, a very large collection of which Dr. Guy A. K. Marshall has kindly placed at my disposal.

MOSQUITO LIFE IN SURREY DURING 1921.

By Lt.-Col. S. P. JAMES, I.M.S. (retd.),

Ministry of Health.

Mr. Malcolm E. MacGregor's interesting paper, "The Influence of Drought upon Mosquito Life in Surrey" (Bull. Ent. Res. xii, p. 205), has led me to examine our records of observations made in that county in connection with inquiries into indigenous malaria in England. As regards certain areas of the county during the past year, our experience of the scarcity of some kinds of mosquitos is the same as Mr. MacGregor's, but (if it is desired to draw conclusions for the county as a whole) it seems important also to note that there are other areas in which the findings differ from those in the particular locality upon which he reported. Dorking, Epsom and Arbrook Common, which are within a few miles of Wisley, are examples of such areas. In these and some other localities in the county we have obtained larvae of *A. bifurcatus* without difficulty throughout the year. At Epsom, large numbers of larvae of this species in the fourth instar were found early in February this year in a well-shaded permanent pool, which we have examined regularly since 1917, and adults were caught in the open in April. Larvae were numerous throughout the year, and adults, both male and female, were captured in the open as late as 22nd October. At Dorking, larvae of *bifurcatus* were plentiful in several natural collections of water throughout the year. One of them—the "Mill Ponds stream"—is only 100 yards from a row of houses; another—the "Stonebridge stream"—yielded *bifurcatus* larvae on 19th August at every place examined along a stretch of 400 yards. On the same day many larvae of this species were found, along with larvae of *C. pipiens*, in the rainwater barrel of a house about 200 yards from the stream.

Next, as regards *A. plumbeus* and *Finlaya geniculata*, we have collected larvae of both species from tree-holes at Dorking and Box Hill on many occasions since the middle of August. Again, the incidence of *Theobaldia annulata* and *Ochlerotatus nemorosus* at Dorking and other localities differed this year from that in Mr. MacGregor's area. Adults of *Theobaldia annulata* were caught in a bedroom at Dorking during July, and larvae have been plentiful in a large stagnant ditch throughout the year. Also it is worthy of note that my laboratory assistant (P. G. Shute) collected from Arbrook Common in June a larva of a species (*Aedes cinereus*) which is not included in Mr. MacGregor's list of the species found at Wisley.

As regards *A. maculipennis*, Mr. MacGregor records the important observation that, when nearly all the available breeding-places in his area were dry, there was an increase in the actual numbers of larvae found in the breeding-places which remained. As well as similar findings, our records contain the observation that this year the river Wey, at Guildford, for the first time since we began to examine it in 1918, harboured many *maculipennis* larvae. During July and August, my laboratory assistant, using a boat, collected numerous specimens along both banks of the river over a distance of a mile.

This and other observations in Surrey and Kent lead us to believe that the presence in our area of *permanent* breeding-places of various kinds sufficiently explains the differences between the records for our area and for the area examined by Mr. MacGregor. In India, where long periods of drought recur annually, the relative

importance of *permanent* and *temporary* breeding-places has been worked out in detail. The account on pages 82-83 of Major Christophers' report on "Malaria in the Punjab"* shows clearly, I think, that what Mr. MacGregor has described as happening in his area this year is what happens each year in certain large tracts of that country. With respect to the various mosquitos which are indigenous in an area, Major Christophers pointed out that, however hard pressed by drought some of them may be in a particular part of the area, it is always possible to find, within their usual distance of spread, some permanent collections of water in which they are breeding freely. Also, that when temporary breeding-places reappear, the various species spread widely from these permanent sources (which he calls "mosquito sanctuaries") until in a short time they can be found again throughout the area. This explains the well-established Indian observation that a particularly dry year has no permanent effect in reducing *Anopheles* mosquitos. In the Punjab the chief *Anopheles* "sanctuaries" were found to be:—(1) Large river-beds like those of the Jumna, Beas, etc.; (2) jheels and large tanks filled with aquatic vegetation, with their associated swamps and pools; (3) extensive brickfields and large excavated pits near towns and villages; (4) irrigation systems.

Nearly the same headings would be applicable to the permanent mosquito "sanctuaries" in Surrey and Kent. As some of them exist within a few miles of the area reported on by Mr. MacGregor, a probable answer, based on Indian experience, can already be given to his question whether the species dealt with will be rare in his locality during future years.

* Scientific Memoirs by Medical Officers of the Government of India, New Series No. 46, 1911.

A NEW APHID GENUS AND SPECIES FOUND IN ENGLAND.

By FRED. V. THEOBALD.

Genus **Laingia**, nov.

This marked genus appears to be intermediate between *Atheroides*, Haliday, and *Sipha*, Passerini.

The characters are as follows: Body elongate in the apterous female. Head somewhat rounded in front to almost flat, moderately large; no frontal or antennal tubercles. Eyes large; ocular process prominent (fig. 1, E, *oc.p.*) and truncate. Proboscis (C) rather short and thick; last two segments of about equal length. Antennae (A) rather short, of five segments, reaching to or just past the pronotum (B). Thoracic segments large and distinct. Legs rather short and thick, the prothoracic

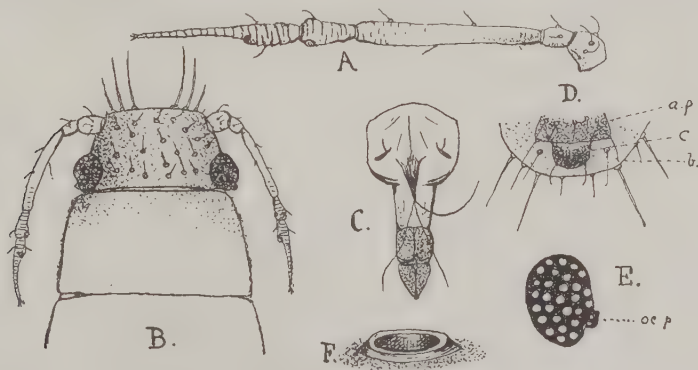


Fig. 1. *Laingia psammae*, sp. n.: A, antenna of apterous viviparous ♀; B, head and prothorax; C, proboscis; D, anal plate (*a.p.*), cauda (*c*), apical segment (*b*); E, eye, ocular process (*oc.p.*); F, cornicle.

pair far from the mesothoracic. Cornicles (F) round, very slightly raised. Cauda (D, *c*) rather small, broad, parallel-sided and slightly convex apically. Anal plate (D, *a.p.*) somewhat rounded apically, broader than cauda, sides straight but divergent; both anal plate and cauda hidden by the prominent semicircular apical segment of the body (D, *b*). Integument finely spinulose. A few short hairs on the body; long, thicker ones on head and apex.

This genus differs from *Sipha* in the non-knobbed cauda and from *Atheroides* in the non-rounded cauda. Superficially it bears some resemblance to *Thripsaphis*, but the ocular processes at once separate it from that genus.

I have named it after Mr. F. Laing, of the British Museum, who pointed out to me that it appeared to be intermediate between *Atheroides* and *Sipha*.

***Laingia psammae*, sp. nov.**

Apterous viviparous female.—Elongate, rather narrow. Colour varying from dull straw to dingy brownish-green. Eyes dark. Legs short, rather thick, darker than body. Abdomen with dusky lateral patches and small dusky spots; apical segment dusky, also apex of cauda; a dusky area around base of cornicles; anal plate dusky.

Antennae of five segments, as long as or a little longer than head and pronotum; 1st segment wider and longer than 2nd; 3rd as long as to a little longer than 5th; 4th small, from one-fourth to a little more than the length of the 3rd; 5th with basal area as long as to a little longer than the 4th; four curved hairs on basal segment; two on 2nd; three to four on 3rd; one on 4th near apex, opposite the sensorium; two on apex of basal area of the 5th; one primary and several secondary sensoria at junction of basal area and flagellum; segments 3-5 imbricated, the last markedly so; at apex three small hairs. The more or less rounded head bears six long thick hairs in front and several shorter ones passing on to the vertex. Eyes large, with prominent quadrate ocular processes. Proboscis rather short and thick, reaching to the second coxae; apical and penultimate segments about equal in length, both dusky. Integument finely spinulose; a few short hairs on body, longest towards the apex. Apical segment rounded, with four long hairs and some short ones, completely covering the cauda. Cornicles round, on slightly elevated cones, which are surrounded by a small dark area. Cauda short and broad, convex at apex, finely spinose, with two long apical hairs; dark, especially apically. Anal plate broader than cauda, sides straight but divergent. Legs rather short and thick, a few hairs on femora; more on tibiae; pro- and mesothoracic pairs widely separate.

Length, 1.9-2.2 mm.

Locality. Littlestone, Kent (vii.1921).

Food-plants.—Marram grass (*Psamma arenaria*) and meadow foxtail grass (*Alopecurus pratensis*).

Found first by Captain A. Duffield, M.C., in great abundance on the marram grass growing on the sandhills near Littlestone. It lives in the blossom heads, usually deeply hidden in the heads, being of much the same colour as the ripening blossoms and consequently not easily detected unless in large numbers. Whilst visiting Littlestone in September I could find no trace of living aphides, but all the ripe grass was smothered with their exuviae and black soot fungus. Mounted exuviae from meadow foxtail grass on the marsh near by show that it had also served as a food-plant. This Aphid produces much honey-dew, which attracted various insects. It was preyed upon by countless ladybird beetles, the chief being *Adalia bipunctata*, and also by many small Syrphid larvae. These, however, had not prevented great numbers of alatae from appearing, for I found large quantities of the cast nymph skins. The grass seed seemed to have been quite ruined by the swarms of this plant-louse.

SOME SIAMESE TABANIDAE.

By Major E. E. AUSTEN, D.S.O.

The potentialities of Siam as a field for discovery have hitherto been almost entirely neglected by collectors of Diptera, and in consequence, apart from an occasional description of a new species, little or nothing has been published upon the Siamese representatives of this Order. It follows that the only available method of making determinations of such material is the exceedingly laborious and wearisome one of reading through descriptions of the older authors like Wiedemann and Macquart, which, though based on types collected in other parts of the Oriental Region, may possibly be found to apply to one or other specimen from Siam.

The following little paper has been prepared in the hope not only of doing something to facilitate the study of Siamese TABANIDAE, but also of arousing interest among those who have the opportunity of collecting these insects within the confines of the kingdom of our eastern ally, so that our knowledge may ere long be extended. The fact that the present paper records only a single species in the case of *Chrysops*, and two species in that of *Haematopota*, is sufficient indication of its incompleteness; of the latter genus, at any rate, it is almost certain that many more than two species are to be found in Siam.

The basis of the paper is a small but interesting collection of Siamese TABANIDAE, recently formed and presented to the British Museum (Natural History), by Dr. M. E. Barnes, of the Rockefeller Foundation, New York, and now of Bangkok. In expressing to Dr. Barnes the grateful thanks of the Museum for his kindness, the author desires to draw attention to the interesting field-notes accompanying many of the specimens, which greatly enhance the value of the collection. As a stimulus to others towards further effort in the same direction, it may be pointed out that, of the seven species of *Tabanus* obtained by Dr. Barnes, no fewer than five appear to be new.

In order, so far as possible, to extend the scope of the paper, the small amount of Siamese Tabanid material previously in the National Collection has been studied in conjunction with Dr. Barnes's specimens and recorded, or, where necessary, described, in the following pages. Unless otherwise stated, however, every specimen mentioned was collected by Dr. Barnes.

It is only necessary to add that the types and paratypes of all new species included in the present paper are in the British Museum (Natural History).

PANGONIINAE.

Genus **Chrysops**, Mg.

Chrysops flavocincta, Ric.

Chrysops flavocinctus, Ricardo, Ann. Mag. Nat. Hist. (7) ix, p. 380 (May 1902).

Three ♀♀, Doi Chom Chang, near Chiangmai, 16.iv.1921. With reference to these specimens, Dr. Barnes writes: "Caught on Doi Chom Chang, while attacking me in a cottage. These flies are very common on the mountain in that region, and are extremely troublesome at a sanatorium situated at an altitude of about 2,500 ft. They were never reported from the top of the mountain (5,500 ft.) until a few cottages were built there, but since that time they are to be found on the peak also."

"They attack very cautiously, approaching their victim from behind, and rarely making for the face. In flight, they somewhat resemble 'Hover-flies,' noiselessly approaching and settling upon the ears, back of the neck, legs, back of the hands, and on the exposed elbows. It is only the severe pain of the bite that attracts the victim's attention, and should the sufferer make the slightest movement, the flies at once effect their escape.

"The wound made by their bite is very painful, and causes much swelling in many people. A minute bleb forms at the site of the puncture, and if the contents be expressed the irritation usually subsides, though the pain and intense itching may persist for several days. If these wounds become infected, as is frequently the case in children, who are very apt to scratch them, they heal very slowly.

"This insect is by far the most troublesome biting fly in the Doi Chom Chang region."

Specimens of *Chrysops flavocincta* already in the National Collection show that the area of distribution of this species, which is one of the smallest of the Oriental representatives of its genus at present known, includes Ceylon, North-eastern India (Khasi Hills, Assam), and Borneo (Sarawak).

TABANINAE.

Genus *Haematopota*, Mg.

Haematopota pachycera, Big.

* *Haematopota pachycera*, Bigot, Nouv. Archiv. Mus. Hist. Nat., Paris (3) ii, p. 206 (1890).

Haematopota validicornis, Ricardo, Rec. Ind. Mus., iv, p. 333, pl. xvii, fig. 23 (1911).

Although this species is not represented in Dr. Barnes's collection, the British Museum (Natural History) possesses a few examples of it from Siam, viz.: 2 ♀♀, precise locality unknown, vi. 1906 (*W. Palmer*); 1 ♀ (type of *H. validicornis*, Ric.), Biserat, 20.x.1901, "in spider's web in jungle" (*Robinson and Annandale*); 1 ♀, Phrapatoon,* 1907 (*Dr. P. G. Woolley*). In addition to the foregoing, the National Collection contains a ♀ of *H. pachycera* from the Federated Malay States (*Dr. A. T. Stanton*, presented by the Imperial Bureau of Entomology).

According to the describer of the species, the type of *H. pachycera* was obtained in the Laos Protectorate, French Indo-China; Miss Ricardo, however, who examined the specimen in the Paris Museum, states (*Ann. Mag. Nat. Hist.* (8) i, p. 59 (1908)) that it is from Cambodia.

Haematopota cilipes, Big.

Haematopota cilipes, Bigot, Nouv. Archiv. Mus. Hist. Nat., Paris (3) ii, p. 205 (1893).

According to Bigot (*loc. cit.*, p. 206), the type of this species was collected in "Laos." The specimen itself (which the writer has been enabled to examine through the kindness and courtesy of Baron J. M. R. Surcouf), however, bears labels stating that it was obtained by M. Pavie in 1886, between Chantabun and Battambang, both of which localities are in Southern Siam. *H. cilipes*, which is not included in Dr. Barnes's collection, is represented in the British Museum (Natural History) by a solitary ♀ from Cambodia, 1909 (*John Surcouf*, presented by Baron J. M. R. Surcouf).

* This place-name is printed here and elsewhere as given on labels attached to the specimens concerned; extensive search in maps and gazetteers, however, has so far failed to identify this Siamese locality.

Genus *Tabanus*, Linn.

Hitherto, so far as it has been possible to discover, only three species of *Tabanus*—*T. rubidus*, Wied., *T. brunnipennis*, Ric., and *T. siamensis*, Ric.—have been recorded or described as occurring in Siam. In the following pages the number of recognised Siamese species of *Tabanus* is raised to fourteen, namely:—

- | | |
|------------------------------------|------------------------------------|
| 1. <i>Tabanus barnesi</i> , sp. n. | 8. <i>Tabanus striatus</i> , Fabr. |
| 2. „ <i>nigrotectus</i> , Big. | 9. „ <i>virgulatus</i> , sp. n. |
| 3. „ <i>insidiator</i> , sp. n. | 10. „ <i>rubidus</i> , Wied. |
| 4. „ <i>praematurus</i> , sp. n. | 11. „ <i>pugnax</i> , sp. n. |
| 5. „ <i>finalis</i> , Walk. | 12. „ <i>pugiunculus</i> , sp. n. |
| 6. „ <i>rubicundulus</i> , sp. n. | 13. „ <i>agnoscibilis</i> , sp. n. |
| 7. „ <i>brunnipennis</i> , Ric. | 14. „ <i>siamensis</i> , Ric. |

It might be supposed, especially in view of what has been stated above with regard to the two species of *Haematopota* mentioned, that one or more of the four species of *Tabanus*—*T. leucosparsus*, *T. nigrotectus* (*Bellardia nigrotecta*), *T. (Atylotus) melanognathus* and *T. (Atylotus) laotianus*—described by Bigot (Nouv. Archiv. Mus. Hist. Nat., Paris (3) ii, pp. 203–205 (1890)) from material stated to have been collected by M. Pavie in the Laos Protectorate,* French Indo-China, would be likely to occur in Siam. As will be seen below, in the case at least of *T. nigrotectus* this surmise is certainly correct.

Of the previously described species recorded in the following pages, two at least—*T. striatus*, Fabr., and *T. rubidus*, Wied.—are widely distributed in the Oriental Region. On the other hand, certain species (*T. barnesi*, sp. n., *T. insidiator*, sp. n., *T. praematurus*, sp. n.) described below appear to be closely allied to, if not the representatives of, other forms which occur in the Naga and Lushai Hills, Assam, so that in their cases the mountain ranges of Upper Burma would seem to form an effective barrier.

Although the subjoined Key has been tested and found sufficient for the determination of the extremely limited amount of material at present available to its author for comparison, infallibility under all circumstances is far from being claimed for it. Nevertheless, it is hoped that it may prove better than nothing, and may also serve to stimulate potential collectors of Tabanids in Siam.

Even assuming that no change in the nature of the characters employed in the Key will be necessitated by the acquisition of further material, it should be noted that, in the case of a given species shown in the table, these characters are only sufficient to distinguish it from the other species included in the present synopsis; they are not necessarily distinctive as regards additional species of *Tabanus*, which may ultimately prove to form part of the Siamese fauna.

It has been necessary to confine the Key to the female sex, since, in the case of the majority of the species tabulated therein, the male is at present unknown. Even so, the characters given for *Tabanus pugiunculus*, sp. n., are perhaps incorrect, since, as will be seen below (p. 453), it is not absolutely certain that the solitary female provisionally assigned to that species really belongs to it.

The number in square brackets [] after the name of a species indicates the serial position of the species in the ensuing pages.

Key to the Fourteen Species of Tabanus recorded below (Females only).

- 1 (2). Wings with first posterior cell closed and petiolate.

- (a) Scutellum smoke-grey pollinose and clothed with silvery-white hair, forming a sharp colour-contrast with remainder of body; smaller species, about 15 mm. in length *barnesi*, sp. n. [1]

* In Kertész's *Cat. Dipterorum*, Vol. III, somewhat quaintly styled the *Laos Islands* ("Ins. Laos").

- (b) Scutellum not smoke-grey pollinose nor clothed with silvery-white hair, entire dorsum of thorax dark mouse-grey, clothed with blackish hair (abdomen black); much larger species, about 20 mm. in length *nigrotectus*, Big. [2]
- 2 (1). Wings with first posterior cell open.
- 3 (4). Colour of scutellum (and hind margin of scutum) sharply contrasting with that of dorsum of thorax between bases of wings; principal pale markings on dorsum of abdomen in shape of two transverse bands; small species *insidiator*, sp. n. [3]
- 4 (3). Colour of scutellum not sharply contrasting with that of thorax between bases of wings, but either identical or at most somewhat paler.
- 5 (6). Dorsum of abdomen beyond the base with paler markings confined to the extreme hind margins of the second and two following segments *praematurus*, sp. n. [4]
- 6 (5). Dorsum of abdomen not so marked.
- 7 (12). Dorsum of abdomen beyond the base with paler markings including or consisting of a series of median triangles or more or less triangular spots, either separate or in part confluent.
- 8 (9). Last two or last three segments of abdomen presenting a sharp colour-contrast with remainder; pale median triangles, large and broad* *siamensis*, Ric. [14]
- 9 (8). No colour-contrast between last two or last three segments of abdomen and remainder; ground-colour of dorsum of abdomen uniform.
- 10 (11). Median triangles or spots on third and two following abdominal tergites more or less confluent *finalis*, Walk. [5]
- 11 (10). Median triangles on second and three following abdominal tergites widely separate *rubicundulus*, sp. n. [6]
- 12 (7). Dorsum of abdomen beyond the base with paler markings including or consisting of a longitudinal median stripe—not triangles or spots, although exceptionally the longitudinal median stripe may take the form of a series of confluent truncate triangles.
- 13 (18). Paler markings on dorsum of abdomen consisting solely of a more or less distinct longitudinal median stripe (no admedian pale markings—not even a sharply defined, pale spot on each side of second tergite).
- 14 (15). Wings distinctly infuscated (strongly tinged with sepia) *pugnax*, sp. n. [11]
- 15 (14). Wings hyaline.
- 16 (17). Wing-stigma conspicuous; front relatively rather broad (4 to 4½ times as long as its breadth between the lower inner angles of the eyes) *pugiunculus*, sp. n. [12]
- 17 (16). Wing-stigma inconspicuous; front narrow (about seven times as long as its breadth between the lower inner angles of the eyes) *agnoscibilis*, sp. n. [13]
- 18 (13). Paler markings on dorsum of abdomen, in addition to the longitudinal median stripe, consisting of an admedian stripe or an admedian longitudinal series of spots on each side, or at least of a sharply defined pale spot on each side of second segment.

* Owing to the completely denuded condition of the type and paratype of *T. siamensis*, Ric. (see below, p. 455), the only specimens of this species at present available, the absolute accuracy of this statement as to the triangles cannot be guaranteed, though the ground-colour presents indications which seem to warrant it.

- 19 (20). Admedian paler markings on dorsum of abdomen practically confined to second segment, which bears a pair of admedian spots (similar spots, if present on any of following tergites, usually much less distinct) *brunnipennis*, Ric. [7]
- 20 (19). Admedian paler markings on dorsum of abdomen not confined to a pair of spots on second segment, but much more extensive (see 18 above).
- 21 (22). Median longitudinal stripe on second abdominal tergite more or less obsolete, at least much less distinct and well developed than on following tergite.. .. . *striatus*, Fabr. [8]
- 22 (21). Median longitudinal stripe on second abdominal tergite not obsolete, in any case just as distinct and well developed as that on following tergite.
- 23 (24). Frontal callus blackish-brown; expanded portion of third segment of antenna cinnamon-rufous *virgulatus*, sp. n. [9]
- 24 (23). Frontal callus chestnut-brown or russet-coloured; expanded portion of third segment of antenna mainly or entirely blackish or blackish-brown *rubidus*, Wied. [10]

1. *Tabanus barnesi*, sp. n. (fig. 1).

♀. Length (one specimen), 15 mm.; width of head, just under 5 mm.; width of front at vertex, 0.6 mm.; between lower inner angles of eyes, 0.4 mm.; length of wing, 15 mm.

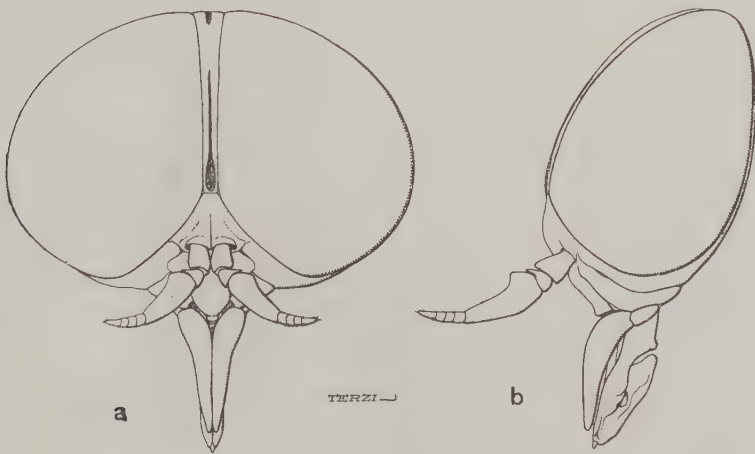


Fig. 1. Head of *Tabanus barnesi*, Austen, sp. n., ♀; a, front view; b, profile.

Dorsum of thorax, except scutellum, olivaceous-black,* scutellum, except extreme base, smoke-grey pollinose, clothed above with silvery white hair; abdomen black, first five (visible) tergites each with a transversely elongate patch of short, whitish, appressed hairs in each posterior angle; wings with costal cells light cinnamon-brown, and a mummy-brown transverse band before distal extremity; first posterior cell closed about 0.5 mm. from wing margin.

* For names and illustrations of colours used for descriptive purposes in the present paper see Ridgway, "Color Standards and Color Nomenclature" (Washington, D.C. Published by the Author, 1912).

Head: Subcallus drab, front, face and jowls greyish-olive pollinose, face and jowls clothed with fine dark-brown or blackish-brown hair, occiput pale smoke-grey pollinose, clothed with fine hair of similar colour, occipital margins fringed posteriorly with short, glistening yellowish hair, except behind vertex, where the somewhat longer hairs are blackish; *front* in ♀ narrow, somewhat wider above than below, clothed with minute, appressed, glistening yellowish hairs, vertex also bearing short blackish hairs, in typical specimen with a median, dark, somewhat shining, elongate mark, but showing no trace of an ocellar tubercle; *frontal callus*, blackish-brown, longitudinally elliptical in outline, and continuous above with a median rib-like extension of same colour, which, in case of typical specimen, reaches a point well above midway between lower end of *front* and hind margin of vertex; *eyes* bare, without recognisable bands in dried condition; *palpi*, drab, proximal segment clothed with fine dark brown or blackish-brown hair, distal segment in ♀ elongate, bluntly pointed at distal extremity, and clothed on outer surface with minute, appressed, black hairs, among which, especially at base above, a number of minute, glistening yellowish hairs is visible; first and second segments of *antennae* cinnamon-buff (pinkish-buff when viewed from above), clothed with minute black hairs, first segment partly embracing second, its upper distal angle being prominent, upper distal angle of second segment considerably produced, third segment cinnamon (infuscated at extreme tip in case of type), fairly deep at base, with a prominent though not elongate angle on upper border, after which expanded portion is somewhat elongate, the part of expanded portion beyond the angle being about twice the length of the part from base to angle inclusive, total length of annulate portion of third segment about half that of expanded portion. *Thorax*: Dorsum (except anterior border, humeral calli, and scutellum, with exception of its black base) clothed with black hair, which is thus present on base of scutellum also; humeral calli clothed with greyish-white hair, upper portion of anterior border of dorsum sparsely clothed with minute appressed, glistening yellowish hairs, a few similar hairs also present among the adjacent black hair; pleurae clothed partly with black, partly with brownish hair; anterior surface of thorax, next to occiput, olive-grey pollinose; pleurae and pectus dark brownish olive-grey pollinose, a thin coating of similar character and colour also present on dorsum of scutum, at least anteriorly, although, at any rate in a partially rubbed specimen, dorsum appears somewhat shining. *Abdomen*: Dorsum somewhat shining; whitish hairs forming lateral patches on dorsum fine and somewhat thinly set, lateral patches on first (visible) segment confined to the actual posterior angles, on following segments corresponding patches are much larger, each patch occupying on lateral margin at least posterior half of the segment, diminishing in depth towards middle line while remaining in contact with hind margin of tergite, and extending over about one-fourth (on fifth tergite about one-third) of the width of the segment; sixth tergite with a few scattered whitish hairs near each lateral extremity; dorsum, except as stated, clothed with short, appressed black hair; venter brownish-black, moderately shining, clothed with short, appressed black hair, among which on hind borders of second and two following sternites, and also scattered over surface of fourth sternite, are short or minute, glistening whitish hairs. *Wings*: Veins mainly dark brown, second longitudinal vein partly, third longitudinal at base, and anterior transverse vein tawny-olive; anterior branch of third vein (at least in type) with a small appendix (in case of type, more noticeable in right wing than in left); *stigma*, tawny-olive, elongate and inconspicuous; first basal cell faintly tinged with sepia; mummy-brown transverse band wider on costa than towards hind margin, and dying away before reaching latter, but extending into fourth posterior cell; on costa, band extends from a point about half-way along lower margin of stigma to end of first submarginal cell; thence, distal margin of band runs obliquely backwards, showing a more or less pronounced indentation in second submarginal cell; proximal margin of band straighter, running across wing practically at right angles to longitudinal axis of latter, and including distal extremity

of discal cell (in the case of the type, in practically every cell crossed by the band the latter is interrupted by a large hyaline streak, so that the band itself is composed of mummy-brown borders to the veins, but this condition is doubtless due to individual aberration). *Squamae*, deep mouse-grey, scantily fringed with fine yellowish hair; borders of *squamae* mummy-brown, outer edges ivory-yellow. *Halteres*, cream-buff, stalks and under surface of knobs more or less mummy-brown. *Legs*: entirely black and clothed exclusively with black hair; front tibiae not thickened; front tarsi in ♀ not conspicuously expanded, but with distal angles of penultimate segment considerably produced.

Chiengmai, 10.v.1921. With reference to the holotype of this species, Dr. M. E. Barnes, in whose honour the author has much pleasure in naming it, writes as follows:—"Caught at about 5.0 o'clock p.m., attacking me while I was seated on the verandah of my house; this is the only specimen that I have seen."

In addition to the foregoing specimen, the British Museum (Natural History) also possesses an old, considerably damaged, and much faded ♀ of this species, taken upwards of fifty years ago at Chantabun, S. Siam (— *Mouhot*), and formerly in the collection of the late W. W. Saunders. While certain differences from the specimen selected as the type are noticeable, none of the points as to which divergence appears can be regarded as more than varietal, and in some respects, as in the condition of the transverse band on the wing, the example from Chantabun is probably the more truly typical of the two. In the Chantabun ♀ the rib-like upward extension of the frontal callus is concealed by the pollinose covering of the front, from a point a little below the middle of the latter; so far as can be seen, there is no trace of lateral patches of whitish hair on the dorsum of the abdomen; the anterior branch of the third vein is without even a vestige of an appendix; and the mummy-brown transverse band on the wing is not interrupted by hyaline streaks.

Tabanus barnesi resembles *T. (Atylotus) nephodes*, Bigot, of which the type, from the Naga Hills, Assam (*Captain Butler*), and a second ♀, from Sibsagar, Assam, are now in the National Collection. While agreeing with the species in question in its wing-marking, and in the first posterior cell being closed at some distance from the wing margin, *T. barnesi* is, however, distinguishable (in the ♀ sex) *inter alia* by its smaller size; by the frontal callus being, if anything, somewhat larger and more clearly differentiated from its rib-like upward extension; by the jowls, pleurae and lower part of the face being clothed with dark brown or black, instead of with whitish hair; by the dorsal surface of the scutellum, except at the base, being smoke-grey pollinose, and clothed with glistening silvery-white hair; by the total absence of median, white-haired triangles on the dorsal surface of the abdomen; and by the appendix to the anterior branch of the third vein, which is long in *T. nephodes*, being vestigial or absent.

2. *Tabanus nigrotectus*, Big.

Bellardia nigrotecta, Bigot, Nouv. Archiv. Mus. Hist. Nat., Paris (3) ii, p. 204 (1890).

Though stated by Bigot to be from "Laos," the type of this species, which Baron Surcouf has most courteously sent to the writer for examination, bears labels identical with those attached to that of *Haematopota cilipes*, Bigot (see above, p. 432). *T. nigrotectus* therefore occurs in Southern Siam. The species was not among those of which examples were forwarded by Dr. Barnes, but is represented in the National Collection by a ♀ from Cambodia, 1909 (*John Surcouf*, presented by Baron J. M. R. Surcouf).

3. *Tabanus insidiator*, sp. n. (fig. 2).

♀.—Length (five specimens), 10 to 10.6 mm.; width of head just under 4 to 4.5 mm.; width of front at vertex, 0.6 mm.; length of wing, 9.4 to 10 mm.

Pretty little species, with, in ♀, two frontal calli, bare eyes having apparently a single transverse purple band on level of lower callus, brightly marked body, and parti-coloured legs.—Pleurae light greyish-olive pollinose, scutellum pale olive-buff pollinose, both clothed conspicuously with pale yellowish hair; dorsum of abdomen mainly chestnut brown at base, then black or blackish-brown, third and fourth (visible) tergites each with a very conspicuous, pale (olive-buff pollinose) hind border, clothed with appressed glistening yellowish hair, and in each case expanded in middle into a wide, low triangle.

Head: Subcallus (in all five specimens available for comparison) shining russet-brown or mummy-brown, sometimes with a small, blackish-brown, median spot above bases of antennae; front greyish-olive pollinose, darker above, face and jaws pallid neutral grey pollinose, clothed with yellowish hair, upper extremities of sides of face immediately below subcallus usually mummy-brown pollinose, occiput smoke-grey pollinose, thinly clothed with pale yellowish hair, posterior orbits on each side of vertex fringed behind with minute black hairs mixed with minute, glistening yellowish hairs, posterior orbits elsewhere fringed with minute, glistening yellowish hairs; *front*, in ♀ of moderate width, somewhat narrower below than above, and in length equal to from five to six times its breadth between lower inner angles of eyes, clothed

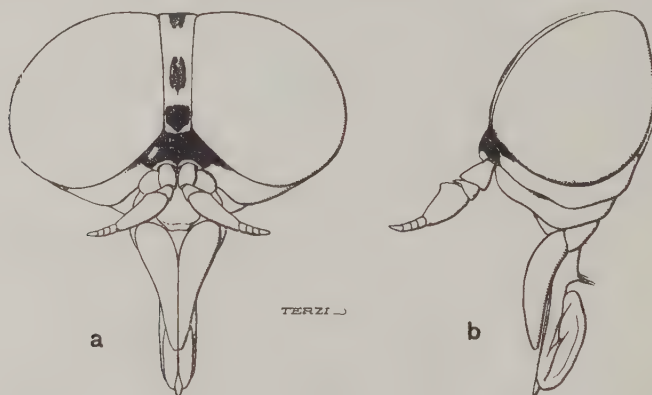


Fig. 2. Head of *Tabanus insidiator*, Austen, sp. n., ♀; a, front view; b, profile.

above with minute black hairs which are longer on vertex, where there is an ill-defined dusky patch but no trace of an ocellar tubercle; *frontal calli* (see fig. 2a), blackish-brown (lower callus sometimes reddish-brown), lower callus shield-shaped or quadrate, its lower margin (except point if shield-shaped) a little above level of lower inner angles of eyes, upper callus elongate quadrate or roughly elliptical, sometimes divided in middle line above, and in some specimens drawn out into a point below, or with a lower median extension which may or may not reach lower callus; *palpi*, neutral grey or deep neutral grey on outer, pallid neutral grey on inner surface, distal segment bluntly acuminate, moderately swollen at base, proximal segment, base and proximal two-thirds of lower margin of distal segment clothed with yellowish hair, outer surface of distal segment clothed elsewhere with minute, appressed black hairs; first two segments of *antennae* pale ochraceous-tawny, expanded portion of third segment tawny or russet, annulate portion cinnamon-brown, second segment and upper portion of first segment clothed with minute black hairs, first segment clothed below with yellowish hair and considerably swollen distally, having its upper distal angle moderately produced and partly embracing second segment, upper distal angle of latter small and not conspicuously elongate, expanded portion of third segment of moderate depth, varying from one-fourth as long again to nearly twice as long as annulate portion, angle on upper margin near base conspicuous

but not produced. *Thorax*: Dorsum—except fore border, scutellum, humeral and post-alar calli, swelling occupying depression at each end of transverse suture, a small area in front of suture immediately above each of these swellings, and extreme hind margin of scutum—blackish-brown, and clothed with similarly coloured hair; anterior surface and fore border of dorsum smoke-grey or light greyish-olive pollinose, the pollinose area extending on each side to transverse suture, and clothed with appressed, glistening yellowish hair; swelling in depression at each end of transverse suture, and area immediately above it in front of suture, pinkish-buff or cinnamon-buff, covered with olive-buff pollen and clothed with longer bright yellowish or ochreous hair, swellings at ends of suture also with a certain number of black or blackish hairs below; humeral and post-alar calli, and extreme hind margin of scutum pale smoke-grey pollinose, and clothed with yellowish hair; pectus agreeing with pleurae in coloration and hairy covering. *Abdomen*: First and second (visible) tergites mainly chestnut-brown, remainder of dorsum, except as already or subsequently described, black or blackish-brown; first (visible) tergite blackish-brown in centre; second tergite with a, not sharply defined, median triangular patch and a blotch on each side (not extending into posterior angle) of same colour; lateral extremities of first (visible) tergite, and posterior angles of second tergite, olive-buff pollinose and clothed with yellowish hair; hind margins of fifth and sixth tergites (sometimes that of seventh tergite also) narrowly olive-buff pollinose, and clothed, at least in part, with hair of same kind as that on hind borders of third and fourth tergites; dorsum, except as stated, clothed with short appressed black hair; venter at base, as far as hind margin of second segment, pale cinnamon or light pinkish-cinnamon pollinose, clothed with yellowish hair; remainder of venter agreeing with dorsum in coloration, markings and hairy covering, except that pale hind borders on third and fourth segments, though of same depth as above, do not exhibit median, triangular expansions. *Wings* strongly tinged with mouse-grey; veins mummy-brown or cinnamon-brown, anterior branch of third longitudinal vein almost rectangular at base, and with an appendix which varies in size in different individuals, and occasionally is entirely wanting; *stigma* tawny-olive, usually fairly well defined and conspicuous. *Squamae* dusky, borders dark brown, fringed with fine, short pale hair. *Halteres* dark brown or blackish-brown. *Legs*: Coxae and trochanters light greyish-olive pollinose, clothed with yellowish hair, hind coxae, at least in front, usually clothed mainly with black hair; femora black, usually more or less greyish pollinose, at least beneath, front femora clothed with black hair, those of middle and hind legs clothed partly with black, partly with yellowish hair; tibiae cream-buff, approximately distal third of front tibiae, and tips of middle and hind tibiae black or blackish-brown and clothed with black hair, cream-buff area of tibiae clothed with fine, glistening silvery hair, with which black hairs (sometimes especially numerous on extensor surface of hind tibiae) may be intermixed; tarsi black, clothed with black hair, third and fourth segments of front tarsi in ♀ only slightly expanded.

Holotype and four paratypes caught on Doi Chom Chang, near Chiangmai, N. Siam, alt. 5,000 ft., 16.iv.1921. With reference to these specimens, Dr. Barnes writes: "Taken while attacking me as I was walking through some jungle. This fly, the bite of which is quite painful, is very common in the jungle on the mountain."

The species just described, although strongly resembling and closely allied to *Tabanus (Atylotus) leucocnematus*, Big., is, in the ♀ sex, distinguishable therefrom *inter alia* by the frontal calli being wider apart; by the expanded portion of the third segment of the antenna being shorter and also deeper at the base; by the short appressed hair clothing the scutellum, post-alar calli, hind margin of the scutum, and hind borders of the third and fourth abdominal tergites being much paler; by the median triangular expansions of the abdominal bands in question being smaller; by the black or blackish-brown tips to the front tibiae being at least twice as deep; and by the wings being somewhat paler, more elongate, more acuminate, and having a more clearly marked stigma.

It may be added that, although the precise origin of the type of *T. leucocnematus*, Big. (now in the National Collection), is unknown, since Bigot (Mém. Soc. Zool., France, v., p. 657 (1892)) records it merely as "Indes," the specimen may well have been taken in Assam. At any rate, the British Museum (Natural History) possesses a second ♀ of *T. leucocnematus*, Big., which was captured at Kolasil, Lushai Hills, Assam, 30.vii.1904, by Captain E. C. Macleod.

4. *Tabanus praematurus*, sp. n. (fig. 3).

♀.—Length (one specimen) 16.2 mm.; width of head, 6 mm.; width of front at vertex, just under 1 mm., between lower inner angles of eyes, 0.4 mm.; length of wing, 15 mm.

Eyes bare, apparently with two (three?) purple bands; a single narrow, elongate, frontal callus in ♀; dorsum of thorax (scutum) tawny-olive pollinose, front and hind borders (including humeral and post-alar calli) and scutellum paler; abdomen, except first (visible) segment, warm blackish-brown (last three segments darker), hind margins of second to fourth tergites inclusive, and of fifth sternite narrowly whitish, and clothed

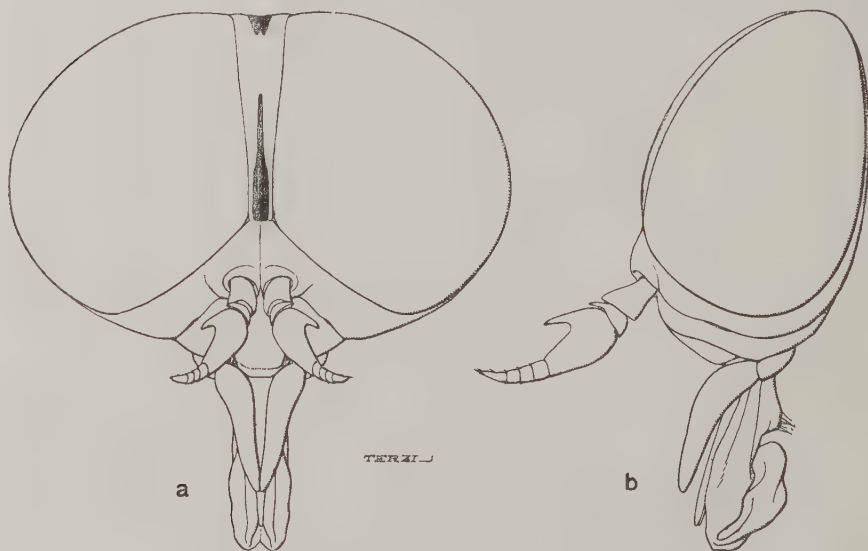


Fig. 3. Head of *Tabanus praematurus*, Austen, sp. n., ♀; a, front view; b, profile.

(except middle third in case of fifth sternite) with appressed yellowish or silvery-white hair, second to fourth sternites inclusive with deeper whitish-grey pollinose hind borders, especially towards the sides, clothed with appressed, glistening, silvery-white hair; wings with base, costal and basal cells tinged with tawny-olive, elsewhere, with exception of a larger or smaller hyaline fleck in almost every cell, suffused with sepia; legs, except coxae, trochanters, extreme tips of femora and bases of middle femora, uniformly blackish-brown or black.

Head: Subcallus, upper part of sides of face and lower half of front cinnamon-brown pollinose, upper half of front darker (mummy-brown), jowls and lower part of face buff-yellow pollinose, occiput ochraceous-buff pollinose, posterior orbits smoke-grey; upper part of sides of face clothed with dark brown hair, jowls and occiput clothed with buff-yellow hair, hind margin of occiput sparsely fringed above on each side of front with glistening hair of somewhat deeper tint; front in ♀ narrow

at its lower extremity, but from level of upper end of main portion of callus to vertex increasing considerably in width (see fig. 3a), sparsely clothed below and on lateral margins with appressed, glistening ochreous hairs, and above with short, erect blackish hair, vertex with a depressed, shining black median area shaped something like a truncate triangle, but with no trace of an ocellar tubercle; *frontal callus* blackish-brown, narrow and elongate, its upper extremity produced into a stout, linear extension, slightly longer than main portion of callus, and reaching to a point a little above midway between level of lower inner angles of eyes and hind margin of vertex; proximal segment of *palpi* clothed below with buff-yellow hair and on upper border of outer side with black hair, distal segment in ♀ acuminate and rather narrow, mouse-grey on outer side except at extreme base, inner side and extreme base of outer cinnamon-drab, outer surface clothed with minute, appressed black hairs, a few glistening buff-yellow hairs at base below; first and second segments of *antennae* light fuscous or olive-brown, clothed with black hair, first segment broadening from base to tip, with its upper distal extremity partially enveloping second segment, upper distal angle of latter strongly produced, third segment russet, expanded portion slightly longer than annulate portion, fairly deep at base, with angle on upper border strongly produced upwards and forwards (see fig. 3). *Thorax*: *Pleurae* dark olive-buff pollinose, scutellum somewhat paler pollinose, dorsum of scutum (in partially rubbed specimen) with more or less distinct traces of four ill-defined, dark brown, longitudinal stripes; dorsum of scutum clothed with fine, erect, glistening honey-yellow hair, *pleurae* and dorsal surface of scutellum clothed with similar hair of a paler (yellowish) tint. *Abdomen*: Tergite of first (visible) segment isabella-coloured, clothed with fine, short, appressed, glistening honey-yellow hair; remaining tergites clothed for most part with short, appressed, black hair, with which on central portion of second tergite honey-yellow hair like that on first tergite is freely mingled; hair clothing whitish pollinose hind margins of second to fourth tergites mainly silvery-white, but some glistening honey-yellow or ochreous hairs also present on or just in front of hind margins of second and third tergites, except at sides; venter at extreme base greyish-olive or neutral grey pollinose; sternite of (nominal) second segment, on each side in front of hind border, clothed for most part with minute, appressed, glistening yellowish hairs; seventh segment clothed above and below with longer black hair; sternites of (nominal) second and following segments, except as already stated, clothed with minute, appressed black hair. *Wings*: Stigma ochraceous-tawny, elongate and tapering; costa, and main stem of third longitudinal vein except at base, mummy-brown, veins otherwise for most part cinnamon-brown or amber-brown; in addition to usual hyaline streak in base of marginal cell, before stigma, and usual hyaline spot on fourth longitudinal vein, immediately before origin of anterior basal transverse vein, all cells, except costal, basal and anal cells, show—at least in typical specimen—a more or less distinct hyaline mark, varying in size and shape in the different cells. *Squamae* pale isabella-coloured (margins lighter or darker according to incidence of light), fringed with pale yellowish hair. *Halteres* cream-buff, base of knobs (in dried condition) cinnamon-brown. *Legs*: *Coxae* dark olive-buff pollinose, clothed with yellowish hair like that on *pleurae*; front and hind trochanters mouse-grey, hind pair clothed partly with yellowish, partly with dark brown hair, trochanters of middle legs cinnamon, with darker markings; middle femora cinnamon at base, extreme tips of all femora cinnamon-buff; tibiae, tarsi, and femora for most part clothed with black hair, posterior surface of middle femora, except at tips, clothed with long and fine yellowish hair, glistening ochreous hairs also present at base of middle femora in front, and at base of hind femora above and below, front femora fringed posteriorly with fairly long black hair; front tibiae not thickened, second and following segments of front tarsi, especially fourth segment, considerably expanded in ♀; claws long, entirely black; pulvilli ochraceous-buff.

Doi Chom Chang, near Chiangmai, alt. 5,500 ft., 15.iv.1921. Writing of the holotype of this species, Dr. Barnes says: "This specimen was caught while attacking

me at dawn in my cottage. On three mornings I was awakened about day-break by attacks by one or more of these flies, which I did not see on any other occasion."

The species described above is allied to *Tabanus manipurensis*, Ric., represented in the British Museum (Natural History), by the holotype ♀ from Ukhrul, Manipur, alt. 6,400 ft. (Rev. W. Pettigrew). Although not unlike *T. manipurensis* in general appearance, *T. praematurus* is distinguishable, *inter alia*, in the ♀ sex by the front being narrower below; by the expanded portion of the third segment of the antenna being much shorter, and having the angle on its upper border much more strongly developed; by the tibiae being uniformly blackish-brown or black instead of conspicuously creamy-white or cream-buff except at the distal extremity and extreme base; and by the greater breadth of the last three joints of the front tarsi.

5. *Tabanus finalis*, Walk.

Tabanus apicalis, Walk., List. Dipt. Ins. in coll. Brit. Mus., i, p. 176 (1848).—*Nomen bis lectum*.

Tabanus finalis, Walk., *op. cit.*, v. Suppl. i, p. 258 (1854).

Although this species is not included in Dr. Barnes's collection, the British Museum (Natural History) possesses a single ♀ of it taken in Siam (precise locality uncertain), 3.ii.1914, "at light" (K. G. Gairdner). The provenance of the type (a ♂) is unknown.

Tabanus finalis is a fairly large (about 18 mm. long), blackish-brown insect of striking appearance, recognisable by the presence of a large, cream-buff median spot on each abdominal tergite from the third to the fifth, inclusive; on the second (visible) abdominal tergite there are three small pale spots in a transverse row, of which the middle one is drab-coloured, while the two lateral ones are smoke-grey; the wings are infuscated, and the veins in the central area to a greater or less extent have brownish borders.

6. *Tabanus rubicundulus*, sp. n. (fig. 4).

♀.—Length (two specimens) 18 to 19 mm.; width of head, 5.6 to 6 mm.; width of front at vertex 0.75 mm., between lower inner angles of eyes 0.4 mm., length of wing 16.25 to 17.2 mm.

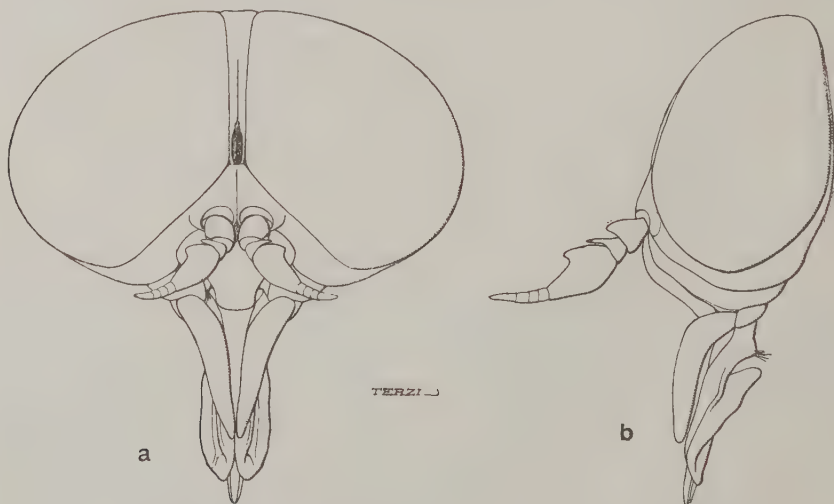


Fig. 4. Head of *Tabanus rubicundulus*, Austen, sp. n., ♀; a, front view; b, profile.

Eyes bare; a single elongate frontal callus in ♀; ground-colour of dorsum of body chestnut-brown; dorsum of abdomen with a median series of conspicuous, light buff

triangles; anterior branch of third longitudinal vein in wing with a well marked recurrent appendix.

Head: Front and subcallus olive-buff pollinose, upper half of front appearing darker when seen from certain angles (looking almost mummy-brown when viewed at a low angle in an antero-posterior direction); face, jowls and occiput pale smoke-grey pollinose, clothed with whitish hair, upper extremities of sides of face faintly suffused with sepia and clothed with dusky or blackish hair, hind margin of upper part of posterior orbits with an inconspicuous fringe of very short black hair, front in ♀ clothed with minute dusky hairs; *front* in ♀ narrow, diminishing in width from above downwards, and about eight or between eight and nine times as long as its breadth between lower inner angles of eyes, ocellar tubercle wanting; *frontal callus* (see fig. 4a), dark chestnut-brown, vertically elongate (roughly elliptical—its base just above lower inner angles of eyes), exhibiting a median impressed line, and continued above into a linear prolongation; *palpi* in ♀ drab-coloured, proximal segment clothed with whitish hair, distal segment narrow and elongate, blunt at tip and but little thicker at base, clothed on outer surface with minute, appressed black hairs; *antennae*, russet, first and second segments clothed with minute black hairs (with yellowish hairs on lower margin of their distal extremities), first segment somewhat greyish pollinose above, strongly swollen distally, its upper distal angle produced and partly embracing second segment, upper distal angle of latter considerably elongate, expanded portion of third segment in ♀ of considerable depth at base, not elongate and having a prominent, blunt angle half-way along its upper margin, annulate portion of third segment (dark chestnut-brown in case of type) about one-fourth shorter than expanded portion. *Thorax*: Dorsum, including scutellum, thinly, pleurae and pectus densely smoke-grey pollinose; dorsum, including scutellum, clothed with semi-erect black hair, mixed with fine, appressed or recumbent, ochreous or yellowish hair, a tuft of whitish hair also present above base of each wing and on post-alar calli; swelling occupying depression at each end of transverse suture, as well as post-alar calli in part and a small area on each side behind and above tuft of whitish hair above base of wing clothed with black hair; pleurae and pectus clothed with whitish hair. *Abdomen*: tergites of second to fifth segments inclusive each with a light buff, median triangle resting on its hind margin, the triangle in each case being formed by a patch of appressed, glistening straw-yellow hairs clothing a light buff pollinose triangular area; in case of holotype and paratype, triangle on second segment is isosceles, and its apex extends somewhat beyond middle of length of segment, while remaining triangles are equilateral and, except in case of triangle on fifth tergite, do not extend as far as middle of their respective segments; lateral extremities of first (visible) tergite pallid neutral grey pollinose, ground colour of lateral extremities, or at least posterior angles of following five tergites ochraceous-tawny; lateral extremities of first (visible) and three following tergites clothed with whitish or silvery-white hair; a small, triangular patch of appressed, glistening straw-yellow hairs on hind margin of first (visible) tergite in middle line, sixth tergite with a more or less distinct, median triangular patch of similar hair, interspersed with minute black hairs, the patch resting on hind margin and showing individual variation in size, being sometimes very small, in other cases considerably larger, so that its apex almost reaches hind margin of preceding segment; owing to absence of a light buff, pollinose ground beneath the median patches of appressed straw-yellow hairs on the first and sixth tergites, these patches are somewhat inconspicuous and do not appear as clearly defined triangles, contrasting sharply with surrounding area, as in the case of the median markings on the four intervening segments; fourth and fifth tergites with a few glistening straw-yellow hairs on their posterior angles; lateral extremities of last three, and hind margins of last two tergites clothed with black hair of moderate length; dorsum, except as stated, clothed with minute, appressed black hairs; venter russet, hind margins (or at least their lateral extremities) of second to fifth sternites, inclusive,

narrowly light buff or cream-buff, entire ventral surface with a thin, pale drab-grey, pollinose covering, which, however, when venter is viewed from behind at a low angle, allows a large, quadrate, not sharply defined, dark median blotch to be seen on each segment from second to sixth inclusive; venter clothed mainly with fine, minute black or blackish hair, seventh sternite clothed as usual with coarse, erect black hairs, lateral thirds of second sternite, lateral fourths of two following sternites except anteriorly, and posterior angles of fifth sternite clothed with glistening, appressed silvery white or yellowish hair, which is longer at lateral extremities of hind margins than elsewhere; entire hind margins of second to fourth (or perhaps, second to fifth) sternites inclusive, sometimes clothed with similar hair. *Wings* sepia-coloured (in life probably considerably darker), an ill-defined, slightly paler area in second submarginal cell; veins lighter or darker mummy-brown, anterior branch of third longitudinal vein forming a right angle with main stem, then bent at an obtuse angle, appendix (at least in case of type and paratype) between 0.4 and 0.5 mm. in length; *stigma* sepia-coloured or dark tawny-olive, narrow, elongate and tapering. *Squamae* sepia-coloured, borders mummy-brown, fringed with short pale hair; *antisquamae* fringed with longer whitish hair. *Halteres* cinnamon-brown, stalks, except distal extremities, and tips of knobs paler (light ochraceous-buff). *Legs*: coxae drab-grey pollinose, front coxae and outer surfaces of middle and hind pairs clothed with fine whitish or yellowish-white hair, lower surfaces of middle and hind coxae, and also part of lower portion of outer surface of middle coxae, clothed with black or blackish hair; femora russet-coloured, darker (more or less blackish-brown) above (at least in case of front legs), upper surfaces of femora clothed mainly with short, appressed black hair, mixed, at least in case of hind pair, with glistening ochreous or yellowish hairs, hind femora also with a tuft of whitish hair at base above; posterior surfaces of front and middle femora clothed with longer whitish hair (mixed above with black or blackish hair in case of front femora), hind femora, with longer whitish or yellowish-white hair below, and with whitish or ochreous hair on lower portion of anterior surface; front tibiae chocolate-brown or clove-brown, and clothed with minute, appressed black hairs, base on outer side paler (indistinctly russet), clothed with minute, glistening, appressed Naples yellow hairs; middle and hind tibiae russet-brown or russet, paler at base, clothed mainly with minute, appressed black hairs, proximal portion of inner surface in case of middle tibiae, and of outer surface in that of hind pair clothed with glistening, appressed, ochreous or yellowish hair, outer edges of extensor surfaces of hind tibiae fringed with longer black hair, flexor surfaces of hind tibiae sometimes largely clothed with appressed, glistening ochreous hairs; front tarsi black, third and following segments strongly expanded in ♀; middle tarsi blackish-brown, likewise with last three segments somewhat expanded; hind tarsi with first segment and proximal two-thirds of second segment russet, otherwise dark brown; all tarsi clothed above with minute black hairs.

S. SIAM: Chantabun (— *Mouhot*:—*ex coll.* the late W. W. Saunders).

In general appearance, as also in the markings on the dorsal surface of the abdomen, and in the narrowness of the front in the ♀, *Tabanus rubicundulus* resembles *T. indianus*, Ric. (Rec. Ind. Mus., Calcutta, iv., p. 175 (1911)), which, originally taken in India (North Kanara, Bombay Presidency), is also found in Hong Kong and Formosa. The new species described above may, however, at any rate in the ♀ sex, be distinguished from the one in question by its differently coloured legs (the femora being paler, and the proximal halves or three-fifths of the front tibiae not being cream-coloured), and by the presence of a well-developed appendix to the anterior branch of the third longitudinal vein.

7. *Tabanus brunnipennis*, Ric.

Tabanus brunnipennis, Ricardo, Rec. Ind. Mus., Calcutta, iv, p. 160 (1911).

Of this species, the type of which is from India (North Kanara), the British Museum (Natural History) possesses a ♀ from Bangkok, collected in 1898 by Major S. S. Flower, O.B.E. Apart from this specimen and the typical series, the only examples of the species as yet contained in the National Collection are from South Malabar (South-west India, a little to the south of the locality where the type and paratypes were obtained).

8. *Tabanus striatus*, Fabr.

Tabanus striatus, Fabricius, Entomologia Systematica, iv, p. 371 (1794).

Tabanus partitus, Walk., Journ. Proc. Linn. Soc., i, p. 9 (1857).

One ♂, Bangkok, 30.viii.1921, caught in donor's house at night, attracted by electric light; only specimen seen: one ♀, Chiangmai, 7.v.1921, on donor's verandah at dusk—a solitary specimen, which did not attack. Two ♀♀ of this species from Bangkok, taken respectively in 1907 (*Dr. P. G. Woolley*) and November 1919 (*F. J. Godfrey*), were previously included in the Museum collection.

The distribution of *T. striatus* is very wide, its range, as shown by material in the National Collection, extending right across the Oriental Region, from North-western and Western India (Kohat and Bombay) to Hong Kong and the Philippine Islands, and including the Federated Malay States, Singapore, Sumatra and Java.

According to Mitzmain,* who studied the bionomics of this species in the Philippines, and also in the same year (1913) demonstrated experimentally its capacity to act as a mechanical transmitter of surra,† *T. striatus* is "the most prevalent horsefly" in the Philippine Archipelago, where, although also attacking cattle and horses, it appears to prey by preference on the carabao (buffalo). As regards human beings, the author referred to writes: "During over two years of personal observation, this fly has never been known to annoy man in the Philippine Islands."

In the dried (pinned) condition, at any rate, apart from their usually darker appearance, specimens of *T. striatus*, especially when the median abdominal stripe is not obliterated on the second tergite, are sometimes liable to be mistaken for examples of *T. tenens*, Walk., of which *T. hilaris*, Walk. (Insecta Saundersiana, i, Diptera, pt. i, p. 49 (1850)), and *T. megalops*, Walk. (List Dipt. Ins. in coll. Brit. Mus., v, Suppl. i, p. 247 (1854)) are synonyms. So far as it is at present possible to judge, the range of *T. tenens* is much more restricted than that of *T. striatus*, though the evidence afforded by the series of specimens in the British Museum (Natural History) shows that this species is common in parts of India (e.g. Madras), and also occurs in Ceylon and Java. In the ♂ sex, excluding differences due to colour, *T. striatus*, Fabr., is distinguishable from *T. tenens*, Walk., by the distal margin of the penultimate segment of the front tarsi being more deeply notched. In its typical form, as represented by specimens from Hong Kong, the ♀ of *T. striatus* may be distinguished from that of *T. tenens*, *inter alia*, by the shape of the lower frontal callus, which is less elongate, i.e., broader in proportion to its length; by the shape of the third and fourth segments of the front tarsi, the sides of these segments when the front legs are viewed from above appearing straighter; and by the legs in general being darker—the femora infuscated, and the front tarsi deep black instead of ferruginous or brownish.

Miss G. Ricardo, in her "Revision of the Species of *Tabanus* from the Oriental Region,"§ involves the identity and synonymy of *Tabanus striatus* in hopeless confusion, since *T. tenens*, Walk., and *T. megalops*, Walk., are included among the

* Cf. M. B. Mitzmain, "The Biology of *Tabanus striatus* Fabricius [*sic*], the Horsefly of the Philippines": Philippine Journ. Sci., viii, no. 3, Sec. B, Tropical Medicine, pp. 197–221, pls. I–VII (June 1913).

† Cf. M. B. Mitzmain, "The Mechanical Transmission of Surra by *Tabanus striatus* Fabricius" [*sic*]: *ibid.*, pp. 223–229 (June 1913).

§ Cf. G. Ricardo, "A Revision of the Species of *Tabanus* from the Oriental Region, including Notes on Species from Surrounding Countries": Rec. Ind. Mus., iv, pp. 150, 153 (1911).

synonyms of *T. striatus*, Fabr., while *T. hilaris*, Walk., is treated as a valid species. Curiously enough, in writing of *T. hilaris* Miss Ricardo says (*loc. cit.*, p. 153): "A species distinguished from *T. striatus*, F., by the short median stripe of abdomen, which does not begin till the *third* segment and by the shorter lateral stripes which usually terminate on the third or fourth segment." The author in question thus appears to regard as distinctive in comparison with *T. striatus*, Fabr., characters which are actually among those given by Fabricius himself as diagnostic of the latter species.†

It may be added that *Tabanus sinicus*, Walk. (List. Dipt. Ins. in coll. Brit. Mus., i, p. 163 (1848))—the type of which, from Hong Kong, is in the National Collection—though included by Miss Ricardo among the synonyms of *T. striatus*, is in reality perfectly distinct. Although allied to *T. striatus*, Fabr., it is, in the ♂ sex, readily distinguishable, *inter alia*, by the greater extent of the area of enlarged facets in the eyes, and by the absence of all trace of a dark band on this area.

The description of *T. striatus* given by Wiedemann (Auss. Zweifl. Ins., i, p. 155 (1828)) would appear to apply better to *T. tenens*, Walk., than to the true *T. striatus*, Fabr.

9. *Tabanus virgulatus*, sp. n. (fig. 5).

♀—Length (one specimen) 16 mm.; width of head, 5.75 mm.; width of front at vertex, 0.6 mm.; length of wing, 13.5 mm.

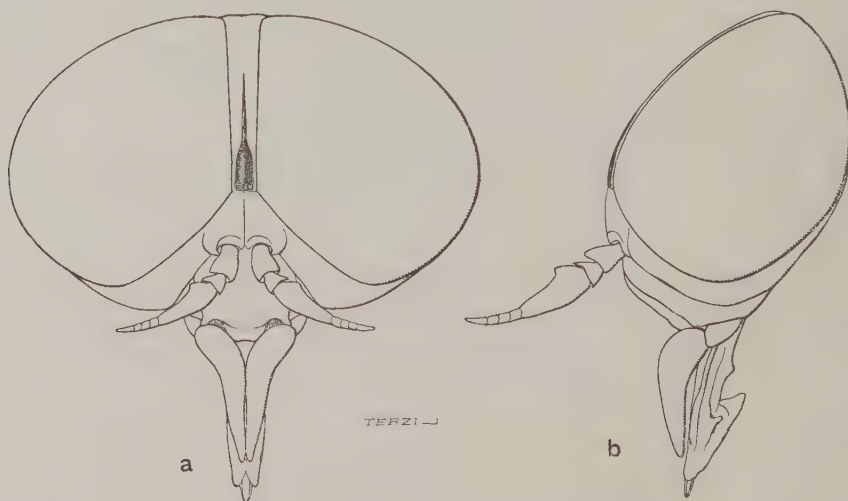


Fig. 5. Head of *Tabanus virgulatus*, Austen, sp. n., ♀; a, front view; b, profile.

Medium-sized species, with dark olive-grey thorax relieved by lighter stripes and dorsum of abdomen blackish-brown, bearing a sharply defined, light buff, longitudinal median stripe, and on each side of this, between it and lateral margin, a longitudinal series of somewhat fainter, light buff ovoid blotches or spots, diminishing successively in size towards posterior extremity, and disappearing before actually reaching it.

Head: Front and subcallus olive-buff pollinose, former clothed with minute blackish hairs above, and with similar pale hairs below; face, jowls and occiput pale smoke-grey pollinose, clothed with whitish hair, hind margin of upper part of posterior orbits

† Fabricius (*loc. cit.*) in his description of *T. striatus* writes: "Abdomen fuscum lineis tribus albis, lateralibus, a basi ad medium ductis, media a medio versus apicem."

fringed with very short and inconspicuous yellowish hair; *front* in ♀ of moderate width, which diminishes very slightly from above downwards, length of front equal to about six times its breadth between lower inner angles of eyes, vertex exhibiting a median, blackish, elongate mark, but ocellar tubercle wanting; a single *frontal callus* (see fig. 5), which is blackish-brown, bottle-shaped in outline and sharply defined, relatively fairly broad yet clearly though narrowly separated from each eye, its lower margin straight and on a level with lower inner angles of eyes, its upper extremity produced into a stout, tapering extension reaching to a point a little above half the length of the front; *eyes* bare (no trace of a band or bands visible in dried condition, in case of type); *palpi* pale pinkish-buff, proximal segment clothed with whitish hair (its outer surface—except tip, perhaps tinged with neutral grey), distal segment considerably swollen at base, then tapering to a slender point, its outer surface clothed with minute, appressed whitish or yellowish-white hairs, mixed with minute, appressed black hairs; *antennae* cinnamon-rufous, annulate portion of third segment (at least in case of type) blackish-brown, distal half of expanded portion infuscated on outer side, first segment light greyish pollinose above, clothed with minute black hairs on upper surface and with yellowish hairs below, its upper distal angle considerably produced and embracing second segment, latter small, its distal extremity ringed with minute black hairs, its upper distal angle small and sharp, not projecting beyond that of first segment, expanded portion of third segment in ♀ narrow and elongate (see fig. 5), with a sharp, prominent angle on upper margin a little beyond end of proximal third, length of annulate portion equal to about three-fifths of that of expanded portion. *Thorax*: Dorsum of scutum longitudinally striped with light olive-grey, in manner frequently seen in genus *Tabanus*—a short median stripe on front border, not extending quite half-way to transverse suture, and on each side of this, between it and lateral margin, a somewhat broader, uninterrupted stripe, reaching to posterior margin of scutum; lateral borders of scutum pale olive-grey, dorsal surface of scutellum unrelieved by lighter markings, its lateral margins light drab; dorsum, including scutellum, clothed with a mixture of minute, appressed cream-buff or yellowish hairs, and short, fine, erect blackish hairs; swelling occupying depression at each end of transverse suture mouse-grey, and clothed mainly with black or blackish hair; a strip on each side, commencing above base of wing and including lower border of post-alar callus, clothed with whitish or silvery-white hair; pleurae and pectus pale smoke-grey, clothed with whitish hair. *Abdomen*: Median stripe on dorsum commencing on first (visible) segment and terminating abruptly on hind margin of sixth, diminishing somewhat in width posteriorly and on second to fourth tergites, inclusive, clearly constituted in each case by a narrow truncate triangle, with its base resting on hind margin; ground colour of stripe smoke-grey pollinose; stripe thus formed is clothed with minute, appressed, glistening Naples yellow hairs, the combined effect being light buff; second to fifth tergites, inclusive, each with a light buff, longitudinally ovoid spot on each side, midway between median stripe and lateral margin, these spots or blotches similar in composition to the median stripe itself, but those on fifth segment very small and faint; sixth tergite on hind margin on each side with a small patch of appressed Naples yellow hairs, representing and in continuation of the spot on the preceding segment, more distinct vestiges of actual spots being visible on sixth segment when abdomen is viewed at a low angle from behind; ground colour of sides of second to sixth tergites, inclusive, cinnamon-rufous; lateral extremities and hind margin of seventh tergite cream-buff, clothed partly with glistening Naples yellow hair, and partly with longer black hair; lateral extremities of first (visible) tergite pallid neutral grey pollinose (posterior angles faintly pinkish-buff) and clothed with whitish hair, lateral extremities of following five tergites whitish pollinose, clothed with glistening whitish or silvery white hair, which towards and on hind margins of posterior segments may merge into glistening Naples yellow hair; dorsum, except as stated, clothed with minute, appressed black hairs; venter, except last segment, cinnamon-drab or light cinnamon-drab, with a more or less distinct though not sharply defined median, quadrate, mummy-brown blotch (resting on front margin but not

reaching hind border) on each segment from second to sixth, inclusive; first (visible) ventral scute with a smaller, blackish, median quadrate blotch, which can be seen between the hind coxae; seventh sternite mouse-grey, with a darker median blotch, smaller than that on preceding segment; hind margins of second to sixth ventral scutes, inclusive, more or less distinctly cream-buff; entire venter with a thin pollinose covering of pale smoke-grey, which, when abdomen is viewed at a very low angle from behind, entirely conceals the median blotches; median blotches on fifth and sixth ventral scutes clothed with semi-erect black hair; terminal segment, except towards lateral extremities of hind margin, clothed as usual with coarse, erect black hair; venter, except as stated, clothed with short, appressed, glistening whitish or yellowish hair. *Wings*: Tinged with mouse-grey; veins chiefly mummy-brown, in places, such as base of third and proximal portion of fifth longitudinal, paler; *stigma* elongate, almost colourless and scarcely distinguishable. *Squamae* smoke-grey or drab-grey, with brownish borders clothed with pale hair. *Halteres*: Knobs cream-coloured, stalks sepia-coloured or paler. *Legs*: Coxae pale smoke-grey, clothed with whitish hair; femora, except extreme tips, black or olivaceous black, with a pale, smoke-grey, pollinose covering, which is, however, largely wanting on the inner side of those of the front legs, and in case of middle and hind femora is denser on lower portion of outer surface than elsewhere; extreme tips of front femora cream-buff, those of middle and hind pairs cinnamon-coloured, all femora clothed with whitish hair; front tibiae, except distal third, which is blackish brown, cream-buff, clothed with minute, appressed, glistening cream-coloured hairs mixed with minute black hairs; middle and hind tibiae pinkish-buff (their extreme tips reddish brown), middle tibiae clothed similarly to those of front pair with a mixture of minute cream-coloured hairs and black hairs, and with longer black hairs on posterior margin of extensor surface; hind tibiae clothed mainly with minute, appressed, glistening cream-coloured hair, and having on outer margin of extensor surface a fringe of medium length composed partly of black, partly of cream-coloured hair; front tarsi black, middle and hind tarsi dark brown or blackish-brown above, proximal segment in case of middle and hind tarsi somewhat paler at base; all tarsi clothed above with minute black hairs, second and following (particularly third and fourth) segments of front tarsi considerably expanded, second and following segments of middle tarsi also somewhat expanded.

BANGKOK, November, 1919 (*F. J. Godfrey*).

The species just described, which is allied to *Tabanus striatus*, Fabr., and to *T. tenens*, Walk. (see above, p. 445), is distinguished from the former of these, in the ♀ sex, by the shape of the frontal callus; by the median longitudinal stripe on the dorsum of the abdomen being as fully developed on the second segment as on the following ones; by the outline of the third and fourth segments of the front tarsus, viewed from above being rounder; and by the distal portion of the expanded part of the third antennal segment being narrower and more elongate. From *T. tenens*, Walk., the new species is distinguishable in the ♀ sex owing to the shape and darker coloration of the frontal callus, and to the expanded portion of the third segment of the antennae being more attenuate.

Tabanus virgulatus is also very closely akin to *T. rubidus*, Wied., and to the Indian *T. priscus*, Walk. (syn. *T. albimediis*, Walk.). As regards the former, it would seem that, in addition to the differences given in the Key above (see p. 435), *T. virgulatus* is distinguishable in the ♀ sex owing to the interval between the lower portion of the frontal callus and the eye on each side being distinctly narrower. It is quite possible that, when further material in good condition and from different countries is available for study and comparison, it will ultimately be found that both *T. virgulatus*, Austen, and *T. priscus*, Walk., are forms of a single widely distributed species, namely *T. rubidus*, Wied.

10. *Tabanus rubidus*, Wied.

Tabanus rubidus, Wiedemann, *Diptera Exotica*, i, p. 69 (1821).

Two ♀♀, foot of Doi Sutep (alt. *circa* 1,200 ft.), near Chiangmai, 7,9,iv.1921. Dr. Barnes's field-note on these specimens runs: "Caught while attacking my horse; a very common fly about horses in this locality."

As-shown by the series of specimens of this species already in the British Museum (Natural History), the range of *Tabanus rubidus* extends at any rate from Bombay to Hong Kong, and includes Nepal, Burma, the Federated Malay States, Singapore, Cochin China and Annam. In Singapore, according to a note by Mr. P. S. Falshaw, *T. rubidus* bites cattle as well as horses; a ♀ from Pahang, Federated Malay States, 2,500 ft., 1916 (*T. R. Hubback*—presented by the Imperial Bureau of Entomology), was taken on a specimen of *Rhinoceros sumatrensis*, Cuv.

11. *Tabanus pugnax*, sp. n. (fig. 6).

♀.—Length (two specimens) 13.4 to 15.2 mm.; width of head, 4.5 to 5 mm.; width of front at vertex, just over 0.5 mm.; length of wing, 12.75 to 13.4 mm.

Eyes bare, apparently with three purple bands; a single elongate frontal callus in ♀; dorsum of thorax, including scutellum, olive pollinose overlaid with greyish,

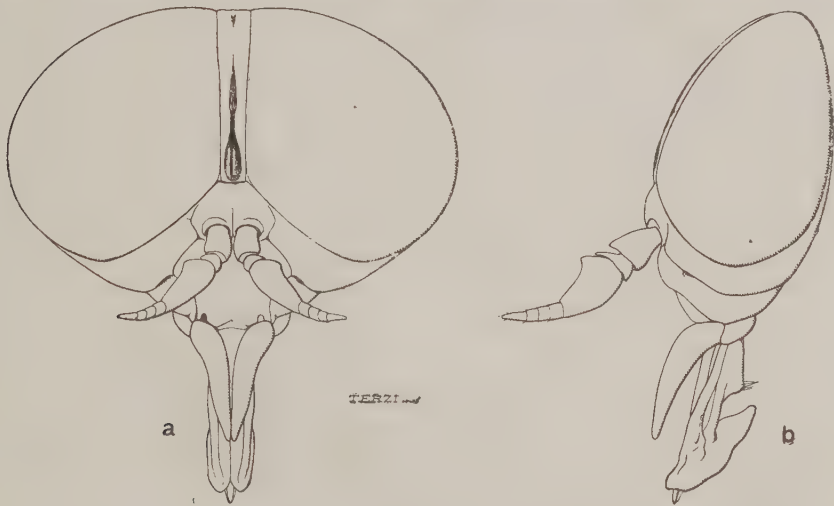


Fig. 6. Head of *Tabanus pugnax*, Austen, sp. n., ♀; a, front view; b, profile.

and uniformly clothed with appressed, glistening Naples yellow hair mixed with fine, erect black hair; dorsum of abdomen, brownish-tawny or brownish ochraceous-tawny, with a more or less conspicuous, median, longitudinal stripe extending from front margin of second (visible) to hind margin of fifth tergite, and composed of a continuous series of truncate, ochreous pollinose triangles, clothed with appressed, glistening buff-yellow hair; fourth and following tergites, otherwise than as already stated, and with exception of hind margins and posterior angles, mainly blackish-brown.

Head: Front ochreous pollinose, clothed, at least on upper half, with minute, fine black or blackish hairs, subcallus, face, jowls and occiput somewhat greyer (dark olive-buff pollinose), sides of face clothed with fine blackish hair, occiput, jowls and remainder of face clothed with pale yellowish hair, hind margin of occiput fringed above with very short and inconspicuous ochreous hairs, interrupted behind vertex by a series of somewhat longer fine black hairs; *front* in ♀ somewhat narrow or of medium breadth, slightly broader above than below, its length equal to about $7\frac{1}{2}$ or 8 times its breadth between lower inner angles of eyes, a narrow, dusky, indistinct, elongate triangular mark on vertex, but no trace of an ocellar tubercle; *frontal callus* (see fig. 6 a), black, bottle-shaped, its base on a level with lower inner angles of

eyes, its upper extremity produced into a lanceolate prolongation extending to a point about two-thirds of length of front above lower margin of latter, bottle-shaped portion marked with a narrow, vertical, median groove; proximal segment of *palpi* greyish-olive pollinose, clothed with fine, yellowish hair, distal extremity of proximal segment vinaceous-buff, sometimes with a few black hairs on outer side above, terminal segment pale cinnamon-brown, elongate and bluntly acuminate, but little swollen at base, clothed on outer surface with minute, appressed black hairs, and with a few minute yellowish hairs on proximal half of under surface; first and second segments of *antennae* cinnamon-drab, clothed with minute black hairs, first segment also with some yellowish hairs below, this segment considerably swollen distally and partially embracing second segment, upper distal angle of latter noticeably produced, third segment ferruginous or orange-cinnamon (terminal annulus blackish-brown in case of type), its expanded portion in ♀ fairly deep at base and not particularly elongate (in case of type, about one-third longer than annulate portion), with a blunt, but well-developed proximal angle on upper margin. *Thorax*: Dorsum somewhat more greyish on anterior border, immediately behind head; swelling in depression at each end of transverse suture agreeing in coloration with remainder of dorsum, but clothed for most part with black or blackish hair, upper and outer surfaces of post-alar calli also clothed mainly with black hair; pleurae and pectus greyish-olive pollinose, clothed with yellowish hair. *Abdomen*: Hind margins of third to fifth tergites, inclusive, narrowly ochreous pollinose, and clothed, at least in part, with short appressed hairs of same colour as those on median stripe; posterior angles of same three tergites and lateral extremities of sixth tergite ochraceous-tawny or cinnamon-buff; hind borders of sixth and seventh tergites more or less distinctly ochreous pollinose; second and third tergites sometimes with a more or less distinct blackish-brown blotch (not reaching hind margin, and larger in case of third tergite) on each side of median stripe, third tergite also with a faint blackish-brown blotch, not reaching lateral margin, at each lateral extremity; hind margin of first (visible) tergite, in median line, with a tiny patch of appressed, glistening, buff-yellow hair; lateral borders of first five tergites fringed with fine, pale buff-yellow hair; hind margin of sixth tergite with a few glistening buff-yellow hairs in median line; dorsum, except as stated, clothed with minute, appressed black hairs; venter cinnamon-coloured, extreme base smoke-grey, remainder when viewed at a low angle from behind seen to be suffused with a dark olive-buff pollinose covering, which is especially pronounced on last four segments; hind margins of second and following sternites deep olive-buff, and clothed with minute, appressed, glistening buff-yellow hairs (sometimes wanting in case of last segment); ground colour of last two sternites, except hind margins (and sometimes extreme lateral extremities of one or both), blackish-brown; second (or third) to fifth sternites, inclusive, sometimes each with a more or less distinct, iron-grey or dark olive-grey, quadrate median blotch, resting on base of segment in each case, but not reaching hind margin, in other cases ground-colour of fourth and fifth sternites, except lateral extremities and hind borders, mainly dark olive-grey; venter, except last segment and apart from what has already been stated, clothed partly with black, partly with appressed, glistening buff-yellow hair, the latter perhaps predominating on second and towards lateral extremities and hind borders of the four following sternites; terminal sternite as usual clothed for most part with longer, coarser, and more erect black hair. *Wings*: Strongly tinged with sepia; veins mummy-brown; *stigma* tawny-olive, narrow and elongate or sometimes inconspicuous. *Squamae* sepia-coloured, with darker borders fringed with pale hair. *Halteres* mummy-brown, stalks and tips of knobs sometimes paler. *Legs*: Coxae, greyish-olive, trochanters brownish-grey, clothed in each case with fine, pale yellowish hair; femora, except extreme tips, blackish-brown or olivaceous-black, more or less densely covered, at least in case of upper and outer sides of middle and hind femora, with greyish-olive pollen, and clothed with hair similar to that on coxae, tips of femora cinnamon-buff; tibiae cinnamon-coloured

(front pair sometimes cinnamon-buff), their distal extremities dark brown, front and middle tibiae clothed mainly with buff-yellow hair, distal extremities in both cases, and distal two-thirds of extensor surface of middle tibiae clothed with black hair, flexor surface of hind tibiae, except at tip, clothed with bright ochreous or ochraceous-orange hair, extensor surface of hind tibiae fringed with black, or black mixed with ochreous hair, tips of hind tibiae clothed with black hair; tarsi blackish-brown (first segment of middle tarsi more or less reddish brown), clothed above with minute black hairs, third and fourth segments of front tarsi in female moderately expanded.

Doi Chom Chang, near Chiangmai, alt. 5,500 ft., 12.iv.1921. Of the holotype and the single paratype of *T. pugnax*, Dr. Barnes writes:—"These flies attacked me at about 10 o'clock a.m., at an altitude of 5,500 ft.; this species is not uncommon."

What would appear to be a variety of *T. pugnax* is represented in the National Collection by two ♀♀ from Siam (precise locality unknown), taken at light, 3.iii.1914 (K. G. Gairdner). These specimens, which are in poor condition, shrunk and partly denuded, having originally been preserved in spirit, differ from the typical form as described above mainly in the coloration of the femora, which are largely or chiefly cinnamon or pinkish cinnamon-coloured, although, in the case of one specimen, those of the hind legs are in places strongly tinged with brownish.

The species just described is allied to *Tabanus fulvime dius*, Ric. (Rec. Ind. Mus., Calcutta, iv, p. 197 (1911)—*nec* Walk.), of Formosa, and to *T. fulvime dioides*, Shirak, (Blood-Sucking Ins. Formosa, Pt. 1, Tabanidae, Taihoku, p. 219, pl. v, fig. 8, pl. xi figs. 6, 7 (1918)), which is stated by its author to be fairly common in the south of Japan. From both of these, however, in the ♀ sex at any rate, *T. pugnax* is distinguishable by its narrower front; by the frontal callus (what is the lower callus in *T. fulvime dioides*, Shir., in which there are two frontal calli) being narrow and elongate, with its upper extremity—instead of suddenly and abruptly contracted, as in *T. fulvime dius*, Ric.—smoothly and directly continuous with the raised, lanceolate ridge representing the upper callus; and by the expanded portion of the third segment of the antenna being deeper and shorter.

12. *Tabanus pugiuunculus*, sp. n. (fig. 7).

♂.—Length (one specimen), 13 mm.; width of head, 4.5 mm.; length of wing, 10.6 mm.

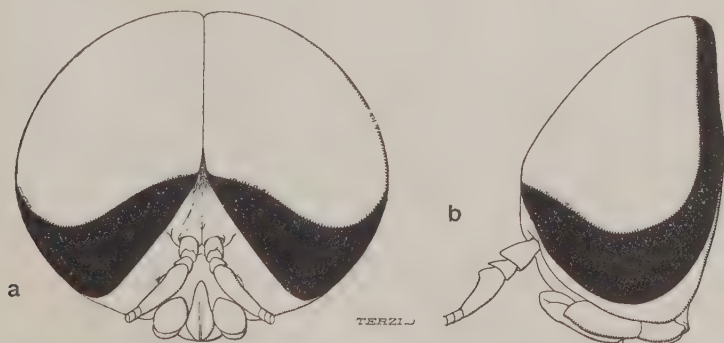


Fig. 7. Head of *Tabanus pugiuunculus*, Austen, sp. n., ♂; a, front view; b, profile.

Dorsum of thorax, including scutellum, deep greyish-olive pollinose, uniformly clothed with minute, appressed, glistening Naples yellow hairs, mixed with fine, erect, cream-coloured hair; dorsum of abdomen russet, fifth to seventh segments, inclusive, except lateral and hind borders, olivaceous black, a smoke-grey pollinose, and from certain angles

not very conspicuous median longitudinal stripe, clothed with minute, appressed, glistening Naples yellow hairs, extending from base of second (visible) to hind margin of sixth tergite; wings hyaline, with conspicuous cinnamon-brown stigma.

Head: Rather less than upper half of frontal triangle in ♂ mummy-brown, remainder of frontal triangle pale olive-buff pollinose, face, jowls and occiput pallid neutral-grey pollinose, clothed with whitish hair, hind margin of upper border of occiput in ♂ without any noticeable fringe of hair; outer extremity of area of enlarged facets in eye of ♂ broadly and bluntly rounded off (see fig. 7), enlarged facets themselves conspicuously coarse, and below and at outer extremity of area sharply differentiated from smaller facets; posteriorly transition to smaller facets is more gradual, though a border, fairly uniform in width, of small facets runs up to and reaches vertical triangle; *palpi*, vinaceous-buff (proximal segment somewhat infuscated on outer side), clothed with hair like that on jowls, interspersed with which on outer side of distal segment are scattered, minute black hairs, distal segment cylindrical, bluntly pointed at tip, not conspicuously swollen; first segment of *antennae* in ♂ light ochraceous-buff, somewhat swollen distally but not embracing second segment, clothed above with minute black hairs and on outside and below with pale yellowish hairs, second segment ochraceous-tawny, its distal margin clothed on outer side with minute black hairs and its upper distal angle but little produced in ♂, third segment tawny (in case of type, distal extremity of expanded portion dark brown and last two annuli missing), expanded portion in ♂ elongate and somewhat narrow, with blunt but prominent angle on upper margin near base. *Thorax:* Dorsum showing indistinct traces of three longitudinal and incomplete, impressed, dusky lines; swelling in depression at each end of transverse suture pale ochraceous-buff pollinose, clothed with fine cream-coloured hair; swelling on each side above base of wing, behind end of transverse suture, pallid mouse-grey pollinose; *pleurae* and *pectus*, at least in type, blackish mouse-grey, clothed with fine, whitish hair. *Abdomen:* Lateral extremities, except lateral borders, of second to fourth tergites inclusive, at least in case of type, more or less dark brown; lateral and hind borders of fifth to seventh tergites, inclusive, as well as posterior angles of fourth tergite, cinnamon-buff or ochraceous-buff; lateral borders of first six tergites with a more or less distinct, pallid neutral-grey pollinose covering, and clothed with pale, whitish hair; first (visible) tergite, except narrow median area immediately behind scutellum, which is clothed with fine Naples yellow hair, and except its lateral borders, clothed with minute, appressed black hairs; second to sixth tergites, inclusive, except median stripe as described in diagnosis above, and except lateral borders, clothed with minute, appressed black hairs, interspersed with minute, appressed glistening Naples yellow hairs; seventh tergite in ♂ clothed exclusively with black hairs; ♂ genital appendages clothed above with black hair, sides of eighth segment in ♂ clothed partly with whitish or yellowish, partly with black hair; first three (visible) ventral scutes and base of fourth orange-cinnamon-coloured, last three ventral scutes and rather more than posterior half of fourth ventral scute, except hind border or hind margins in case of fourth to sixth scutes inclusive, olivaceous black; first three ventral scutes each with an ill-defined dark mouse-grey or olivaceous-black median blotch, not reaching hind border in either case, but otherwise quadrate and extending full length of segment in case of first two visible segments, transverse and occupying less than posterior half in case of third segment; posterior borders or margins of third to sixth ventral scutes inclusive cream-buff; entire venter light neutral grey pollinose, second (visible) and three following segments, as well as hind margin of sixth segment clothed with appressed cream-buff hair, last two ventral scutes clothed with erect black hair, coarser as usual in case of last scute, and mixed with minute, appressed cream-buff hairs in case of penultimate scute. *Wings:* Costa blackish-brown, veins otherwise mummy-brown. *Squamae* light drab, borders mummy-brown. *Halteres*, knobs blackish-brown or clove-brown, stalks tawny-olive. *Legs:* Front coxae light neutral grey pollinose, middle and hind coxae

neutral grey or deep neutral grey pollinose, all three pairs of coxae clothed with whitish hair; front femora olivaceous-black, neutral grey pollinose on outer side below, clothed with fine black hair, which on lower border of outer side of distal half is mixed with whitish or yellowish white hair; middle and hind femora mouse-grey (their distal extremities greyish cinnamon-coloured), clothed, except outer surface of middle femora, with whitish hair, outer surface of middle femora clothed with black hair; tibiae, except rather less than distal half in case of front pair, and rather less than distal fourth in that of middle and hind pair, ochraceous-tawny, distal extremities of front tibiae blackish-brown or olivaceous-black, those of middle and hind tibiae reddish-brown, tibiae clothed with black hair (flexor surfaces in case of middle and hind pairs clothed with appressed cinnamon-buff hair), extensor surfaces of hind tibiae (at least in ♂) fringed with fine and fairly long black hair; tarsi black (middle pair missing in case of type), first segment of hind pair paler (sepia-coloured), all tarsi clothed with minute black hairs.

Near Bangkok, vi.1921, caught in a railway carriage. With reference to this species, Dr. Barnes writes:—"I have seen a number of specimens of this fly."

What is quite possibly the opposite sex of *T. pugiunculus* to that of the type is represented in the National Collection by a solitary ♀ taken at Phrapatoon, in August, 1906 (*Dr. P. G. Woolley*). While agreeing with the type in many respects, such as in the presence of a pale (Naples yellow-haired) longitudinal median stripe on the dorsum of the abdomen, in the character of the wings (including the shape and coloration of the stigma), and in having strongly infuscated femora, this specimen exhibits certain differences—notably in the expanded portion of the third segment of the antennae being much deeper and entirely tawny (not dark brown at the tip); in the dorsum of the abdomen being mainly dusky (fuscous, or olivaceous-black), instead of russet with a dusky distal extremity; in the venter (apart from hind margins of segments) being uniformly neutral grey, without any trace of dark median blotches; and in the pale portion of the front tibiae being clothed with glistening yellowish (Naples yellow) hair. The *front* is relatively rather broad (4 to 4½ times as long as its breadth between the lower inner angles of the eyes); and there is a single, rather large, mummy-brown *frontal callus*, in shape resembling an isosceles triangle, with its lower margin just above the level of the lower inner angles of the eyes, and its upper extremity produced into a narrower extension, nearly one-third of the *front* in width, which dies away at a point about one-third of the length of the *front* from the hind margin of the vertex. The dimensions of this specimen are as follows: length, 10.5 mm.; width of head, 3.6 mm.; width of front at vertex, 0.5 mm.; length of wing, 9 mm.

As regards species liable to be confused with *T. pugiunculus*, it may be mentioned that the British Museum (Natural History) contains three ♂♂ of a (possibly undescribed) species of *Tabanus* from Lower Burma (base of Dawna Hills, 4.iii.1908, *Dr. N. Annandale*), which at first sight closely resemble that described above. These specimens, however, may be distinguished by *inter alia*, their smaller heads, the absence of a definite area of greatly enlarged facets in the eyes, and their pale femora.

Finally it may be remarked that *Tabanus pugiunculus* presents a certain superficial resemblance to the Javanese *T. cinerascens*, Big., but is distinguishable, *inter alia*, by its infuscated femora.

13. *Tabanus agnoscibilis*, sp. n.

♀.—Length (one specimen) 10.4 mm.; width of head, 3.2 mm.; width of front at vertex, 0.4 mm.; length of wing, 9 mm.

Small species, with apparently bare eyes, narrow front and single frontal callus in ♀, dorsum of thorax uniform deep greyish-olive, and tapering abdomen which, except last

three segments, which are blackish-brown, is ochraceous-tawny above; dorsum of abdomen also with a paler, median, longitudinal stripe.

Head: Subcallus and front in ♀ except vertex, tawny-olive pollinose, face, jowls, occiput and vertex pale smoke-grey pollinose, upper extremities of sides of face adjoining subcallus faintly tinged with tawny-olive; jowls and hinder edge of posterior orbits below clothed with pale yellowish hair, fringe of similar hair on hinder edge of upper part of posterior orbits so short as to be scarcely discernible; *front* in ♀ only very slightly narrower at lower than at upper extremity, and without trace of an ocellar tubercle; *frontal callus* tawny-olive, elongate and roughly longitudinally cylindrical-ovate in outline, with its lower end just above lower inner angles of eyes, and its upper extremity produced into a linear extension, the reddish-brown termination of which reaches to a point about half-way up the front; *palpi* pinkish buff, clothed on outer side with minute, appressed black hairs, proximal segment below with longer yellowish hair, distal segment in ♀ elongate acuminate, moderately swollen at base; first and second segments of *antennae* cinnamon-coloured (first segment somewhat pallid neutral grey pollinose above), clothed on outer surface with minute black hairs, first segment expanded as usual from base to tip, but its upper distal extremity not enveloping second segment, upper distal angle of latter not conspicuously produced (third segment wanting in case of type). *Thorax*: Dorsum, including scutellum, clothed with short, glistening, appressed Naples yellow hair, lateral border of dorsum and dorsal surface of scutellum smoke-grey pollinose, swelling occupying depression at each end of transverse suture with a vinaceous-buff ground colour, and sparsely clothed below with longer, erect black hair; pleurae and pectus smoke-grey pollinose, and clothed with fine whitish hair. *Abdomen*: Paler, median, longitudinal stripe light pinkish-cinnamon pollinose on ochraceous-tawny, smoke-grey pollinose on blackish-brown portion, extending from hind margin of first (visible) to hind margin of sixth tergite, inclusive, and clothed with minute, appressed, glistening Naples yellow hairs; lateral borders of first six tergites somewhat smoke-grey pollinose, and clothed with hair similar to that on median stripe; dorsum otherwise than as already stated clothed with minute, appressed black hairs; first four ventral scutes pinkish-cinnamon, clothed with minute, appressed, glistening Naples yellow hairs, last three ventral scutes blackish-brown; fifth and sixth ventral scutes somewhat greyish pollinose, clothed with appressed blackish hair, mixed on fifth scute with minute, glistening Naples yellow hairs, seventh ventral scute clothed as usual with coarse, erect black hair. *Wings*: Hyaline, with cinnamon-brown or paler veins; *stigma* ochreous, elongate, not conspicuous. *Squamae* light drab or drab-grey, with pale-haired borders. *Halteres* cream-buff, stalks somewhat darker. *Legs*: Coxae smoke-grey or mouse-grey pollinose, clothed with whitish hair; front legs, except coxae, blackish brown, distal fourth of front femora and rather less than proximal half of front tibiae cinnamon-coloured; middle and hind legs, except coxae, ochraceous-tawny, bases of femora and upper surface of tarsi, except practically whole of first and extreme base of three following segments, more or less dark brown; front legs, apart from coxae, mainly clothed with black hair, posterior border of upper surface of femora clothed with fine, yellowish hair; middle and hind legs clothed mainly with yellowish (yellowish white) hair, upper surface of hind femora and outer edges of extensor surfaces of hind tibiae also with minute black hairs; front tarsi not expanded.

SIAM (precise locality uncertain), 3.ii.1914, "at light" (K. G. Gairdner).

The type of this species might easily be regarded as a ♀ of *T. pugiunculus*, Austen, were it not for the exceedingly pale stigma, differently coloured halteres and much less infuscated femora. Should it after all prove to be conspecific with the ♂ that has been treated as the type of *T. pugiunculus*, the ♀ provisionally regarded as belonging to that species will represent a new one.

14. *Tabanus siamensis*, Ric.

Tabanus siamensis, Ricardo, Rec. Ind. Mus., iv, p. 212 (1911).

This species, the provenance of which is given by its author simply as "Siam," is not represented in the series obtained by Dr. Barnes. The type and paratype, both of which are completely denuded as well as somewhat shrivelled, and were evidently preserved in spirit before being pinned, are in the National Collection. A moment's glance at either specimen is sufficient to show that what Miss Ricardo describes as the "shining black" colour of the thorax is simply due to excessive denudation—doubtless caused by washing about while in alcohol. The pollinose covering of the dorsum of the thorax, of which vestiges are still conspicuous, is isabella-coloured, so that, although not the slightest trace of hair is now discernible on the dorsum, it is clear that, whatever be the actual colour of the latter in this species, it is certainly not "shining black."

NEW SPECIES OF AFRICAN SIMULIIDAE AND FURTHER STUDIES OF THE EARLY STAGES.

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(Plates XIII & XIV.)

It has been stated by Malloch and other authors that the superficial differences between the various species of *Simulium* in the adult stage are often so minute as to be discernible only after a very careful study of the genus. Previous studies had led the writer to believe that the characters of the pupal respiratory filaments would prove to be of constant specific value, but further investigation has caused this view to be modified with regard to the actual branching, though the structure of the chitinous wall and the general appearance still seem to be constant specific characters.

In the case of one species described in this paper, *S. hirsutum*, and the varieties *S. hirsutum* var. *dubium* and *S. hirsutum* var. *adersi*, though the branching of the filaments varies very considerably, even in the same pair of filaments from the same individual pupa, yet the chitinous structure of the filament wall appears to be the same in all specimens.

The difference in the position and actual number of the branches seems quite understandable from a morphological point of view and may be explained on the supposition that the filaments primarily arise from three main stems, which form into a single stem at the base. The pupa of the var. *dubium*, though bearing the same number of branches as the type that has been selected as the true *hirsutum*, namely eight, differs in that the branching takes place, in the case of the second and third main stems, at a very considerable distance from the base.

These two forms were taken from the same locality and were in the greatest number amongst the specimens obtained, though individuals were taken at the time showing considerable variation in the distance of the branching point from the base. With regard to the form *adersi*, this was obtained from a very different locality and altitude, but it will be seen from the figure given (Pl. xiv, fig. 6) that the first main stem has developed a further branch, the second main stem divides again into two more branches and in the case of the third main stem the branching appears to have retracted until the three branches arise from nearly the same point. The position of the branching of this form appears to vary very considerably in a series of specimens, but no difference can be observed in the chitinous structure of the outer wall. The male genitalia, wing venation, hind claws of the female, and the general appearance and colour of the adults of all these three forms appear to be the same.

A similar case of variation in the pupal branching occurs in the species *S. alcocki*, *S. alcocki* var. *violaceum* and *S. alcocki* var. *coalitum*, described in this paper. The adults of these varieties appear to differ slightly in colour, but in no definite structural character.

The actual position of the branching of the filaments may depend a great deal on the growth of the larva. Taylor* states that the rudimentary pupal filaments are developed in the very young larvae at the same time as the imaginal rudiments; on this point the writer is fully agreed.

* Taylor, T. H., Trans. Ent. Soc., London, 1902, pp. 701-716.

Two pupae of entirely different species have been obtained by the writer in which the pupal filaments coalesce for a very considerable distance before branching, forming a peculiar long main stem. In the case of one of these pupae, described in this paper as *S. alcocki* var. *coalitum*, the imago was well developed within, and the male genitalia were dissected out, proving identical with those of the true *S. alcocki*.

As regards the other aborted form, the imago was not sufficiently developed to allow of a positive determination, but from the number of the branches and the chitinous structure of the outer wall, it seems to be a form of *S. hirsutum*. It is rather remarkable that only single specimens of such aborted pupae were found among some hundreds of pupae collected and examined, and that the same type of malformation occurred in two very different species. It is suggested that this may be due to some adverse condition during the growth of the larval stage.

The writer is now engaged on a monograph of the genus, and from present knowledge it would seem that the inter-relation of the species may be best determined from the combined characters of the wing venation, the male genitalia, the hind claws of the females and the chitinous structure and general appearance of the pupal filaments.

***Simulium hirsutum*, sp. nov.**

♂. *Length*, 1.4 mm. *Antennae* black, covered with short grey pubescence. *Thorax* velvet-black, covered with deep golden pubescence. *Pleurae* brown, lacking patch of soft hairs on membranous area. *Wings* hyaline, radius unforked. *Abdomen* velvet-black, with iridescent patches on the 2nd, 5th and 6th segments, abdominal scale bearing a fringe of long yellow and brown hairs, the first three segments covered with golden pubescence dorsally. *Legs*: front legs rich brown, the femora covered with dull golden hair; hind legs, coxae brown, with a few pale yellow hairs, remainder of leg rich purple-brown, covered with brown hairs and a few scattered golden hairs, second tarsal joint with deep excision near base. *Genitalia* (Pl. xiii, fig. 1): basal pieces large; claspers about half the length of the basal pieces, very peculiarly constructed, the interior margin being extended and folded over into a rectangular flap, the apex of the clasper pointed and bearing a "bill-shaped" finger-like process; anal plates not very well defined and bearing a fringe of stout bristles on the outer margin; adminiculum very broad, bearing a well defined pouch covered with short curved hairs arising from well defined pits; arms ending mesally in a single rather short and very stout spine turned outwardly.

Habitat.—Described from six specimens reared from pupae found attached to grass blades in a swift-flowing mountain stream.

TANGANYIKA TERRITORY: Morogoro, 21.xi.1917.

Type in the British Museum.

♀. *Length*, 1.5 mm. *Head*: frons and face dark purple-grey, covered with golden pubescence; *antennae* dark purple-brown, covered with dark grey pubescence. *Thorax* and *scutellum* very dark purple-brown, almost black, covered with golden pubescence. *Pleurae* brown, lacking patch of soft hairs. *Wings* hyaline, radius unforked. *Abdomen* deep brown, thickly covered with light golden hairs. *Legs*: front legs deep purple-brown, femora and tibiae covered with coppery pubescence; hind legs purple-brown, the pubescence darker at joints and interspersed with a few light yellow hairs, especially on the tibiae and metatarsi; tarsi dark brown, second tarsal joint with excision near base, claws with a prominent tooth at base.

Habitat.—Bred from pupae from same locality and on same date as male type. Not found biting.

Pupa, type form (Pl. xiv, fig. 4).—The respiratory filaments are eight-branched, arising from three main stems: the first dividing dichotomously; the second dividing

dichotomously and then dividing once again, forming three in all; and the third dividing dichotomously and once again in the same way but nearer the base. This is a very common type.

Pupa var. **adubium**, nov. (Pl. xiv, fig. 3).—The filaments are eight in number, but the second stem divides again very much more distally from the base, and the third main stem divides again at about two-thirds the entire length from the base.

The typical pupa and this variety were taken from the same locality and on the same date as the male type.

Pupa var. **adersi** nov. (Pl. xiv, fig. 6).—The respiratory filaments are 11 in number, arising from three main stems at base: the first divides into three branches; the second divides into three, the first two again dividing dichotomously, making five in all; and the third divides into three very near the base. The position of the branching of the third main stem varies greatly, even in the filaments on either side of the same individual. The same number and general arrangement seems very constant in this form, no really intermediate forms having been obtained as yet.

EAST AFRICA: Zanzibar, 22.vii.1917, from grass blades in small stream.

The genitalia of the males, the female structure and the general coloration of the adults appears to be the same in all specimens bred from or dissected from the three types of pupae.

Simulium alcocki, sp. nov.

♂. *Length*, 1.5 mm. *Antennae* dark brown, covered with grey pubescence, the first two segments naked and distinctly reddish-brown. *Thorax* and *scutellum*, very dark velvet-brown, covered with light golden pubescence. *Pleurae* fuscous, lacking patch of soft hair. *Wings* hyaline, radius unforked. *Abdomen* velvet-black, basal scale bearing a long fringe of pale yellow hairs, a diagonal lustrous blue stripe on either side of the 2nd, 5th and 6th segments. *Legs*: front legs, coxae and femora straw-coloured, dark brown at apex, tibiae straw-coloured, dark brown just at basal joint, more so at apex, tarsi dark brown; hind legs, coxae yellow, femora yellow, brown at apex, tibiae yellow, dark brown at base and apex and along outer margin, metatarsi pale yellow, dark brown at apex and along inner margin, remainder of tarsi brown, second tarsal joint with slight excision near base. *Genitalia* (Pl. xiii, fig. 4): basal pieces large; claspers about two-thirds the length of the basal pieces, rather thick, tapering at apex, which bears a short finger-like process; anal plates long, rather cup-shaped at apex and bearing numerous hairs and bristles; adminiculum broad, apical margin forming a lip covered with a fringe of short curved hairs; arms ending mesally in a single long strong spine, turned back outwardly.

Habitat.—Bred from pupae attached to grass blades in slow-moving stream.

NIGERIA: Ibadan, 500 ft., 6.xii.20.

Type in the British Museum.

♀. *Length*, 1.6 mm. *Head*: frons and face grey, covered with silver pubescence; *antennae* fuscous, covered with short grey pubescence, the first two and part of the third segments deep orange. *Thorax* dark lustrous grey, completely covered with dense brassy pubescence in the case of freshly emerged specimens, silvery towards outer margin. *Pleurae* brown, lacking patch of soft hairs. *Wings* hyaline, radius unforked. *Abdomen* dark brown, the first six segments covered with golden hair, the 7th and 8th tergites rather bare, shining, with a few sparse black bristles. *Legs*: front legs, coxae yellow, femora and tibiae yellow, dark brown at joints, tarsi brown; hind legs, coxae yellow, femora yellow, black at apical joint, tibiae brown, yellow at base and banded yellow across middle, metatarsi pale yellow, dark brown at apex, remainder of tarsi black, second tarsal joint with excision near base; claws with prominent tooth at base.

Habitat.—Bred from pupae found at same locality and date as male type. Not found biting.

Paratype in the British Museum.

Pupa, type form (Pl. xiv, fig. 7).—Respiratory filaments seven-branched, arising from three main stems. The first main branch divides dichotomously at some distance from base; the second divides dichotomously and once again, making three branches in all; the third divides dichotomously at some distance from the base, but arises in conjunction with the second rather than from the main base.

Pupa var. violaceum, nov. (Pl. xiv, fig. 8).—The respiratory filaments differ from those of true *S. alcocki* in being ten-branched, and arise from the main base at a wider angle. The third main stem subdivides into five branches in all.

The adults appear to differ slightly in coloration, the males having a more pronounced violet area on the sides and on the dorsal portion of the first segment of the abdomen. There appears to be no difference in the characters of the male genitalia.

Habitat.—Pupae obtained and adults reared from same locality and on same date as the type of *S. alcocki*, also on subsequent dates.

Types in the British Museum.

Pupa var. coalitum, nov. (Pl. xiv, fig. 1).—The respiratory filaments of this form show a very peculiar development. The branching takes place at a very considerable distance from the main base, there being 10 branches in all. The general arrangement is similar to that in *S. alcocki* var. *violaceum*, but the branches seem to have been welded together as the result of malformation. The genitalia of the male imago, which was well developed within the specimen obtained, showed no difference in character from those of the true *S. alcocki*. More material may show that this form is a reversion or modification of some earlier type from which both the forms *S. alcocki* and *S. violaceum* have evolved, especially as a similar case occurs with *S. hirsutum*.

Simulium divergens, sp. nov.

♂. *Length*, 1.7 mm. *Antennae* light brown, covered with fine light pubescence. *Thorax* deep velvet-brown, covered with light golden pubescence. *Pleurae* light brown, lacking patch of soft hair. *Wings* hyaline, radius unforked. *Abdomen* deep velvet-brown, almost black, covered with light golden hairs dorsally, lower surface of abdomen light brown. *Legs*: front legs with coxae and femora honey-yellow, tibiae light brown at base and apex, tarsi very dark brown, almost black; hind legs with coxae yellow, femora yellow, with very dark brown area at apex, tibiae dark brown, pale at basal joint and across middle, tarsi almost black, second tarsal joint with excision near base. *Genitalia* (Pl. xiii, fig. 3): basal pieces broad; claspers about two-thirds the length of basal pieces, the distal portion turned almost at right angles, the apex of the outer margin pointed and bearing a very short single finger-like process; anal plates broad, inner margin with a fringe of short spines; adminiculum very broad, bearing a narrow pouch in centre covered with short hairs arising from distinct pits; arms very strong and ending mesally in a single very strong blunt spine, turned outwardly, behind which lies a thin membranous area more strongly defined along the dorsal margin.

Habitat.—Bred from pupae attached to grass blades in slow-moving stream.

NIGERIA: Ibadan, 4.xii.1920, 500 ft.

Type in the British Museum.

Described from a single specimen bred from pupa and from a specimen dissected from pupa.

♀. *Length*, 1.7 mm. *Head* with frons and face dark brown, pollinose, covered with pale yellow pubescence; antennae dark brown, covered with minute pubescence, 1st, 2nd, and part of 3rd segments honey-yellow. *Thorax* black, with dull greenish tints, covered with light brassy pubescence, silvery towards sides, the usual lyre-shaped vittae prominent; scutellum covered with very long pale brassy hairs. *Pleurae* dark brown, lacking patch of soft hairs. *Wings* hyaline, radius unforked. *Abdomen* dull brown, first three segments covered with sparse yellowish hairs dorsally, last three segments shining dorsally and covered with sparse yellowish hairs. *Legs*: front legs with coxae yellow, femora and tibiae yellow, dark brown at apical joints, tarsi brown, almost black; hind legs with coxae yellow, femora yellow, but dark brown at apex; tibiae dark brown, pale yellow at apical joint and diagonally across middle; basal two-thirds of metatarsi yellow, remainder of tarsi brown, almost black, second tarsal joint with excision near base, claws with prominent tooth at base.

Habitat and *locality* the same as for male type. Not found biting. Described from a single specimen bred from an isolated pupa.

This species is closely allied to *S. aureosimile*, Pomeroy, but differs in some of the characters of the male genitalia, the coloration of the female, and in the structure of the pupal filaments.

Pupa.—Cocoon strong, but somewhat loosely woven, of the wall-pocket type, but without "side openings." Respiratory filaments four-branched (Pl. xiv, fig. 2). The first two arise from a main stem, which is narrowed at base. The remaining pair branch from a stem at a short distance from the main base. The angle between the filaments is very wide. The ends of the branches are rounded and the chitinous wall is rather weak. The surface of the chitin, which is covered with minute nodules, is very different in appearance from that of *S. aureosimile*. Pupa described from the specimen from which the male type emerged.

Simulium vorax, sp. nov.

♀. *Length*, 2.5 mm. *Head* with frons and face grey, covered with shining yellow-grey pubescence; antennae dark brown, covered with very short fine grey pubescence, the 1st, 2nd and part of 3rd segments clear brown-orange. *Thorax* dark lustrous grey, brown-grey at sides, the lyre-shaped vittae very dark, prominent and curved; the entire surface in fresh specimens covered with thick light greenish-golden pubescence; scutellum covered with long greenish-golden hairs. *Pleurae* brown-grey, pollinose in some lights, lacking patch of soft hairs. *Wings* hyaline, radius unforked. *Abdomen* dull velvet-black, thickly covered with shining yellow-grey pubescence arranged in whorls, the last three segments less dull, and the 8th and 9th segments with long pale yellow-grey hairs interspersed among the pubescence. *Legs*: front legs, dark brown, the coxae and basal half of the femora and basal two-thirds of tibiae covered with shining yellow-grey hair, tarsi dark brown, almost black; hind legs dark brown, basal half of femora and basal two-thirds of tibiae covered with shining yellow-grey hair, tarsi rich dark brown, almost black, basal half of metatarsus, with exception of inner margin, covered with shining yellow-grey hair, second tarsal joint with excision near base, claws simple, with no tooth.

Habitat.—Taken biting voraciously and engorging on donkey near stream.

Described from 35 specimens taken at same time and place; ♂ unknown.

TANGANYIKA TERRITORY: Amani, 14.xii.1917.

Type in the British Museum.

This species is very near to *S. neavei*, Roub., but differs especially in size, and in the shape and colour of the thorax, which is uniformly dull black in the latter species.

Simulium unicornutum, Pomeroy.*

♂. *Length*, 1.5 mm. *Antennae* fuscous, heavily covered with silver-grey pubescence. *Thorax* velvet-black, covered with thick golden pubescence; metathorax slate-blue and scutellum black, both covered with thick golden pubescence and long golden hairs. *Pleurae* fuscous, lacking patch of soft hairs. *Wings* hyaline, radius unforked. *Abdomen* velvet-black, with iridescent violet-blue patches on 2nd, 5th and 6th segments. *Legs*: front legs with coxae, femora and tibiae honey-yellow, dark brown at the apex of the tibiae and a dark brown spot at the apex and near the base of the femora, tarsi black; hind legs with coxae fuscous, femora honey-yellow, dark brown at apex; tibiae dark brown, banded yellow at apex and across middle; basal two-thirds of metatarsi pale, remainder of tarsus black, second tarsal joint with excision near base. *Genitalia* (Pl. xiii, fig. 2): basal pieces rather broad; claspers a little longer than the basal pieces and rather tapered towards the apex, which bears a single finger-like process; anal plates rather short, bearing a clump of bristles at apex and a few stout hairs at base; adminiculum very broad, concave at the centre, which bears a patch of numerous small curved hairs; arms very strong, ending mesally in a single long spine turned outwardly.

Habitat.—Bred from pupae attached to grass blades in small stream.

NIGERIA: Ibadan, 500 ft., 6.viii.1920, 9.xii.1920, 11.xii.1920.

Described from specimens bred from isolated pupae corresponding in all details to the type. Material placed in the British Museum.

♀. *Length*, 2.6 mm. *Head* with frons and face silver-grey, with light golden pubescence; antennae fuscous, covered with fine grey pubescence, 1st, 2nd and part of 3rd segments dull orange. *Thorax* and *scutellum* very dark grey, covered with light greenish-golden pubescence. *Pleurae* dark brown, lacking patch of soft hairs. *Wings* hyaline, radius unforked. *Abdomen* dark brown, basal scale with fringe of long golden hairs, the three basal segments covered with golden pubescence, the last three segments shining dorsally. *Legs*: front legs with coxae and femora honey-yellow, tibiae yellow, banded dark brown just above base and at apex, tarsi dark brown; hind legs with coxae and femora honey-yellow, latter dark brown at apex, tibiae dark brown, banded yellow at base and across middle; basal two-thirds of metatarsus yellow, remainder of tarsus dark brown, second tarsal joint with excision near base, claws with prominent thick tooth at base.

Described from many specimens of same date and from same locality as males and bred from isolated pupae corresponding in all details to the type. Not found biting.

Material in the British Museum.

Simulium palmeri, sp. nov.

♂. *Length*, 1.5 mm. *Antennae* black, covered with short grey pubescence. *Thorax*: prothorax velvet-black, covered with thick golden pubescence, increasing in area laterally and diminishing toward the median line; mesothorax velvet-black, covered with thick dark purple-brown iridescent pubescence; metathorax shiny slate-blue, dotted with a few sparse black hairs; scutellum fuscous, covered with dark hairs. *Pleurae* fuscous, lacking patch of soft hairs. *Wings* hyaline, radius unforked. *Abdomen* velvet-black, covered with black hairs; an iridescent violet patch on the sides of the 2nd, 5th and 6th segments. *Legs*: front legs with coxae fuscous; femora fuscous, middle portion heavily covered with silvery pubescence, brassy in some lights; tibiae covered with silvery pubescence, dark brown at apex; tarsi almost black and very hairy; hind legs with coxae black; femora deep purple-brown; tibiae light golden-yellow at base, remainder deep purple-brown, with a

* Pomeroy, Ann. Mag. Nat. Hist. (9) vi, 1920, p. 79, pl. iii.

band of golden-yellow pubescence across basal third; tarsi almost black, second tarsal joint with excision near base, claws with distinct tooth at base. *Genitalia* very similar to those of *S. unicornutum*, Pomeroy; the general size appears to be smaller and the adminiculum not so long and the styli more prominent.

NIGERIA: Ubiaja, 15.i.1921.

Type in the British Museum.

Described from pupae found in swift hill-stream, alt. 900 ft. Bred from isolated pupae.

♀. *Length*, 1.5 mm. *Head*: antennae fuscous, covered with silver-grey pubescence, 1st, 2nd and part of 3rd segments honey-yellow; frons bare, slate-blue pollinose; face fuscous-blue pollinose in some lights, bare except for a few black bristles. *Thorax* dark brown, shining, covered with dark brown pubescence and with a few golden hairs, more numerous in front and laterally; scutellum fuscous, covered with long black bristles. *Pleurae* fuscous, lacking patch of soft hairs. *Wings* hyaline, radius unforked. *Abdomen* very dark brown, almost black, thickly covered with black hairs, last four segments shining dorsally. *Legs*: front legs with coxae fuscous, femora brown, with a pale yellow area at middle and along frontal margin, tibiae dirty yellow, banded dark brown just below base and at apex, tarsi dark brown; hind legs with coxae yellow, femora dark brown, paler at middle, tibiae dark brown, pale yellow at basal joint and with an oblique yellow band across middle; basal two-thirds of metatarsus yellow, remainder of tarsus brown, second tarsal joint with excision near base, claws with thick prominent tooth.

Described from specimens reared from isolated pupae taken on same date and from same locality as male type. Not found biting.

This species differs distinctly from *S. unicornutum*, Pomeroy, in the darker colouring of the legs, the colour and pubescence of the thorax, especially the scutellum, and also in the colour of the frons and face. There is no appreciable difference in the male genitalia, except in size and possibly in the adminiculum. The pupa, however, is very distinct and constant in the formation of the respiratory filaments, and on the several different characters of this and the adult stage the writer considers it to be a distinct species.

Pupa.—The respiratory filaments are somewhat similar to those of *S. unicornutum*, and consist of a single bent tube on either side (Pl. xiv, fig. 5). The angle at the base, however, is very distinct and more acute, and the tube is constricted into a series of globes. This globular appearance is very noticeable in the natural state, and in prepared mounts it may be seen that it is the result of the arrangement of the chitin forming the walls of the tube. The cocoon is of the wall-pocket type, very strong and without side openings. Described from many specimens similar to that from which male type emerged. Taken same locality and date. Material placed in the British Museum.

EXPLANATION OF PLATE XIV.

Respiratory Filaments of Pupae of *Simulium* from West Africa.

- Fig. 1. *Simulium alcocki*, sp. n., var. *coalitum*, n.
„ 2. „ *divergens*, sp. n.
„ 3. „ *hirsutum*, sp. n., var. *dubium*, n.
„ 4. „ *hirsutum*, sp. n.
„ 5. „ *palmeri*, sp. n.
„ 6. „ *hirsutum*, sp. n., var. *adersi*, n.
„ 7. „ *alcocki*, sp. n.
„ 8. „ *alcocki*, sp. n., var. *violaceum*, n.



Male Genitalia of West African species of *Simulium*.

- Fig. 1. *Simulium hirsutum*, Pomeroy, sp. n.
 2. " *unicornutum*, Pomeroy.
 3. " *divergens*, Pomeroy, sp. n.
 4. " *aleocki*, Pomeroy, sp. n.



Respiratory filaments of pupæ of *Simulium*.

SOME NATURAL ENEMIES OF MANGO LEAF-HOPPERS (*IDIOCERUS* SPP.) IN INDIA.

By T. V. SUBRAMANIAM,

Assistant Entomologist, Mysore Department of Agriculture.

(Plates XV & XVI.)

To entomologists in India the three species of mango Jassids—*Idiocerus niveosparsus*, *I. atkinsoni* and *I. clypealis*—are fairly well known, both on account of their wide distribution and also on account of the serious damage they do to the mango crop. In the course of our studies on these important orchard pests we have within the past three years come across three natural enemies of the adult hopper and one of the nymph. These are (1) a Pipunculid fly; (2) a Stylopid—both internal parasites; (3) an Epipyropid moth—an external parasite of the adults; and (4) a Dryinid wasp—an external parasite of the nymphs.

The following are some observations so far made regarding the above-mentioned parasites.

1. The Pipunculid Fly (*Pipunculus annulifemur*, **Brun., sp. n.**)*

This is a small dark-coloured fly with a large head and large globular compound eyes of a dark reddish colour (Pl. xv, fig. 6). The female fly is provided with a very sharp, fairly long, honey-coloured ovipositor, which is held pressed against the ventral side of the abdomen. All the three species of hoppers are parasitised by this insect, but *I. atkinsoni* is the least attacked.

Egg-laying by the flies has not been observed as yet. Full-grown and young maggots have been observed on the hoppers during November and December. The young maggots are of a rich orange colour and have the peculiar habit of hopping, like fruit-fly maggots, when placed on a smooth surface.

The parasitised hoppers are very sluggish, the abdomen being much bloated and tense. They seek dark and shady places underneath the leaves of mango or other trees growing near by, fix their rostrum to the leaf tissue, and remain in that condition. The full-grown maggot now makes a way out through the dorsal surface of the abdomen, between two segments. The maggots drop to the ground and pupate under the soil. The full-grown maggot (Pl. xvi, fig. 2) is pale-coloured and oval in shape, with the anterior extremity narrowed and blunt. It is 5 mm. long and 3 mm. across. The spiracle shows as a small funnel-shaped black depression, a little away from the extreme posterior end, on the dorsal surface. The pupal period lasts for 14 to 19 days in captivity.

The characteristic appearance of a number of hoppers adhering to the lower surface of the leaves of mango trees in shady places, with the abdomen partly split asunder, is a sure indication of the work of this parasite (Pl. xvi, fig. 1).

2. The Stylopid Parasite (*Pyriloxenos compactus*, **Pierce**).

Dissection of a number of mango leaf-hoppers to find out the percentage of parasitisation by the Pipunculid fly led me to the discovery of this parasite. The female parasites (Pl. xv, figs. 2, 3) are very small, dark brown, elongate ovate creatures,

* For the description of this species, see p. 469.

with two very small tubercular projections, one on each side, at the anterior extremity, and a semicircular slit-like opening in the middle of the cephalothorax ventrally. The ventral portion of the cephalothorax behind this slit-like opening is slightly arched, and its terminal portion is elongated, V-shaped and black in colour. The dorsal part of the cephalothorax rests against the abdomen of the host, and is as broad as the ventral part, but only half as long. Its posterior extremity ends in a very uneven serrated edge, the serrations pointing outwards. Both the V-shaped ventral and the serrated dorsal end of the cephalothorax, as also the six-segmented abdomen, are buried permanently in the abdomen of the host. Thus only the anterior portion of the cephalothorax is found projecting from the pleuro-ventral side of the abdomen of the host, generally towards the anal end.

As the ova develop and the larvae are formed, the ovisac occupies the major portion of the abdominal cavity of the host (Pl. xv, fig. 4). Over 1,000 larvae were counted coming from a single ovisac. These larvae are very small, active, fish-like creatures of a pale yellow colour, with two long bristles on the last abdominal segment (Pl. xv, fig. 5); they were observed suddenly shooting out into space through the slit opening on the ventral side of the cephalothorax of the female, which projects from the abdomen of the hopper. This was noticed in a hopper a few minutes after its death. The mode of the entry of the larvae into living hoppers has not yet been observed.

The male puparium is seen as a small globular brown body, very much resembling one end of the pupa of a Muscid fly, with a cap anteriorly, on the pleuro-dorsal side of the hopper (Pl. xvi, fig. 6), partly covered by the wings of the latter. The major portion of the remainder of the pupa is buried in the abdomen of the host. Generally only one individual is found in a hopper, but sometimes two or three males and females are found in the same insect, especially in *I. atkinsoni*, which species is very heavily parasitised. The male puparium is sometimes found on the ventral side of the abdomen.

Before the emergence of the adult male, the two large compound eyes and the head are clearly visible through the pupal shell. The male pushes out the cap-like anterior extremity and escapes, leaving the pupal case projecting from the abdomen like a cylinder. The hoppers survive only a few days after the emergence of the male. The adult males are dark, very slender, active creatures with a pair of large wings (Pl. xv, fig. 1). The antennae are seven-jointed, the terminal five joints each broadened and foliaceous. The insects are very active in flight, and are able to crawl slowly on the sides of a glass beaker. They lived only eight to ten hours after emergence from the pupae in captivity.

I. niveosparsum has never been found styloipised; 30 per cent. of *I. atkinsoni* and 15 per cent. of *I. clypealis* were found parasitised in one year. Misra mentions (Pusa Memoirs, v, pt. 2, 1917, p. 124) a Stylopid parasite of the sugar-cane leaf-hopper. The parasite of the mango leaf-hoppers appears to be quite different.

3. The Epipyropid Moth (*Epipyrops fuliginosa*, Tams, sp. n.)*

The oviposition of this moth on the hoppers has not yet been observed. The caterpillar is small and cream-coloured, and is found attached by the anal end to the side of the last thoracic segment of the hopper underneath the wings, with the head facing posteriorly (Pl. xvi, fig. 4). The full-grown caterpillar is as long as the abdomen of the hopper (3-3.5 mm. long and 2 mm. thick), and the body is thick and stout towards the head, which is found very close to the anal end; but in young larvae the head reaches only to about one-third or one-fourth of the length of the abdomen. All the three species of hoppers are parasitised.

* For the description of this species see p. 468.

It is not definitely known on what these caterpillars feed. To find this out, a number of hoppers with the parasites in different stages were minutely observed in captivity. The larger caterpillars were found to irritate (scrape?) the sides of the abdomen with the mouth-parts, and the young caterpillars treated in the same way the soft portions between the abdomen and the thorax dorsally. Very small quantities of some whitish wax-like matter was noticed all about the caterpillars, but no damage to the abdomen of the hoppers was evident. I am not sure if they fed on this white waxy matter. The hoppers seemed in no way inconvenienced by the presence of these parasites on them, and they were alive and quite active for a long time after the parasites had left them for pupation.

Pupation takes place underneath the leaves of the mango or on the stems, in a bright white tough silken cocoon (Pl. xvi, fig. 3). If the parasites are on *I. niveosparsus*, pupation takes place on the main trunk and branches where the hoppers rest; if they are on the other two species, pupation takes place underneath the leaves. In 1919 the white cocoons of these parasites were found in such large numbers underneath the leaves and on the trunks of the trees in a garden in Bangalore, that they were at first mistaken for a bad attack of the common scale-insect, *Pulvinaria psidii*; but the absence of "sooty mould" and the shining appearance on the leaves were very marked. The caterpillars do not act as a control on the hoppers to the slightest extent.

4. The Dryinid Wasp.

During the mango blossoming season many of the hopper nymphs were found moving on the flower-stalks and leaves with small, dark, round objects attached to the pleural side of the posterior end of the third segment of the thorax, which were found to be the grubs of a Dryinid wasp. There is a dark sac-like covering enclosing the grub, which is cast off along with the moulted skin of the hopper nymphs.

The full-grown grub is of a rich cream colour, very thick at the posterior end and tapering to a point anteriorly (Pl. xv, fig. 7). Pupation takes place in a thin silken cocoon. We have not yet been able to rear the adults from the grubs in captivity, so that the species has not been identified. In no case were the nymphs found to survive the attack of the parasite. All the three species of hoppers were attacked.

* * * * *

The following table shows the percentage of parasitism of the hoppers by the different parasites.

	<i>I. niveosparsus.</i>		<i>I. atkinsoni.</i>		<i>I. clypealis.</i>	
	1919.	1920.	1919.	1920.	1919.	1920.
Pipunculid fly	15%	Very few	5%	Extremely few	10%	2%
Stylopid parasite.. .. .	Nil	Nil	30%	3%	15%	3%
Drynid wasp	3%	Less than 1%	10%	2%	5%	1%
Epipyropid moth	75%	2%	Very rare.	Very rare.	10%	Nil
Total	93%	3%	45%	5%	40%	6%

In conclusion I have to state that the above observations were made by me in the mango gardens in Bangalore; the study of the life-history and bionomics is being continued. I am greatly indebted to Dr. Coleman, the Director of Agriculture in Mysore, for the ready help and great encouragement shown to me.

DESCRIPTION OF A NEW SPECIES OF EPIPYROPS FROM SOUTH INDIA.

By W. H. T. TAMS.

***Epipyrops fuliginosa*, sp. n.** (Pl. xv, fig. 8).

Male.—General coloration fuscous, with the vertex of the head, pectus, underside of abdomen, anal region, legs and base of antennal shaft mouse-grey. Fore-wings, above, covered with mouse-grey scales, amongst which are scattered irregular patches of fuscous-black scales, these predominating but forming no definite pattern; beneath, covered more uniformly with fuscous-black scales, except in the region between the first anal vein and the inner margin, which is covered with narrow elongate oval mouse-grey scales. Hind-wings above and beneath covered with fuscous scales, the inner margin furnished with long fuscous hairs. Cilia of both wings fuscous-black.

Female.—Coloration as in male, but fore-wings with more uniform covering of fuscous-black scales above and beneath, and less mouse-grey scaling on the underside.

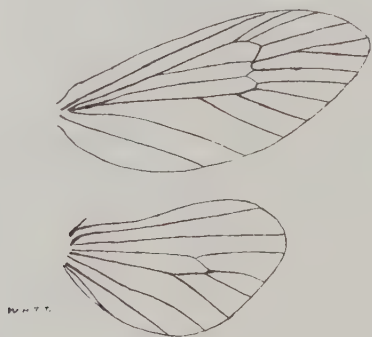


Fig. 1. Neuration of *Epipyrops fuliginosa*,
Tams, sp. n.

Expanse of male 10 mm.; length of body 3 mm.; antennae 2 mm. long, with twelve bipectinations, the longest two-thirds of length of antennae.

Expanse of female 8 mm.; length of body 3 mm.; antennae 1 mm. long, with eight bipectinations and one unpaired pectination at base of shaft, the longest about a quarter of length of antennae.

Fore-wing neuration (fig. 1). The male type and two fragmentary specimens have veins 7 and 8 connate, and not stalked as in the drawing.

Hind-wing neuration. The costal region has two veins (?6 and 8) apparently free from base to termen (compare with Perkins' figure of neuration of *Palaeopsyche*). Vein 8 is well developed, ?6 and 5 are very weak. Anal region with the second anal vein (1*b*) well developed, the first (1*a*) and third (1*c*) very weak.

Male type and female, from Bangalore (T. V. Subramaniam), in poor condition. Also two males and a female in bad condition.

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A NEW PIPUNCULID PARASITIC ON LEAF-HOPPERS IN INDIA.

By E. BRUNETTI.

Pipunculus annulifemur, sp. n. (Pl. xv, fig. 6).

Head.—Eyes dark red; vertical triangle black, frons dull black, lower part with a somewhat quadrate greyish dust spot; face dull black, lower half appearing grey when viewed from above. Antennae dull yellowish, third joint distinctly pointed, moderately long and almost sub-triangular. Occiput moderately produced behind eye margins, black, with a little grey dust. *Thorax* moderately shining black, middle of dorsum with yellowish brown dust and a little pale pubescence; pleurae blackish, with some greyish dust. *Abdomen* shining black; a very little yellowish pubescence towards sides; genitalia with a yellowish tinge. *Legs* mainly yellow; coxae black, also a broad median band on femora (possibly incomplete in some individuals); tarsi darker towards tips; all femora with a row of very small bristles on about apical half of underside. *Wings* clear; stigma very pale yellow; anterior cross-vein at about two-fifths of the discal cell; halteres yellowish. *Length*, 2.5–3.5 mm.

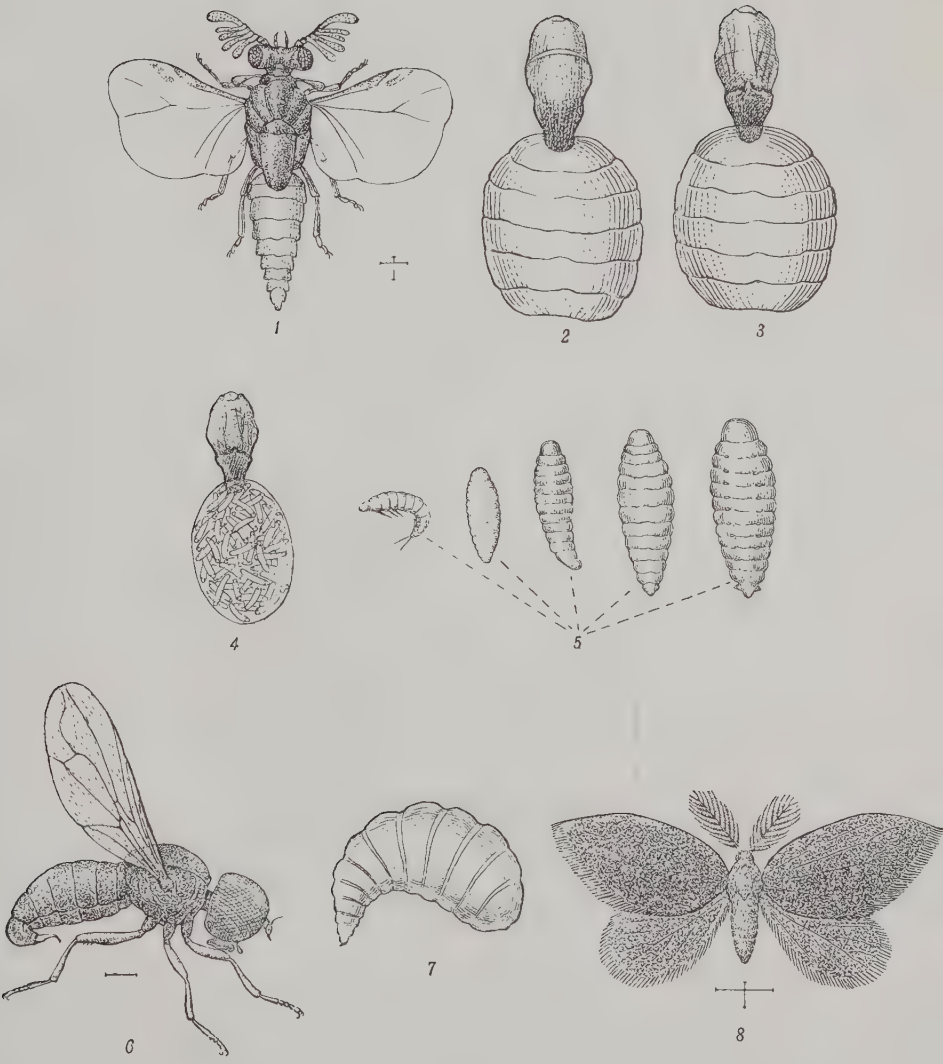
MYSORE STATE: Bangalore, about 3,000 ft. (T. V. Subramaniam).

Described from two males in the British Museum.

EXPLANATION OF PLATE XV.

Parasites of Mango Leaf-hoppers (*Idiocerus* spp.).

- Fig. 1. *Pyrilloxenos compactus*, Pierce, ♂.
- „ 2. „ „ „ ♀, ventral view.
- „ 3. „ „ „ ♀, dorsal view.
- „ 4. „ „ „ ♀, showing the ovisac full of triungulins.
- „ 5. Different stages of the larva of *P. compactus*.
- „ 6. *Pipunculus annulifemur*, Brunetti, sp. n., ♀.
- „ 7. Full-grown larva of Dryinid parasite.
- „ 8. *Epipyrops fuliginosa*, Tams, sp. n., ♂.

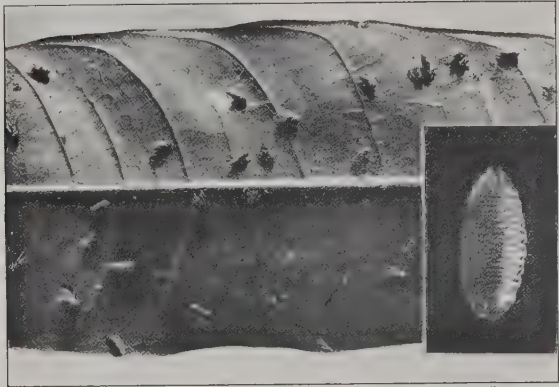


Parasites of the Mango Leaf-hoppers.

EXPLANATION OF PLATE XVI.

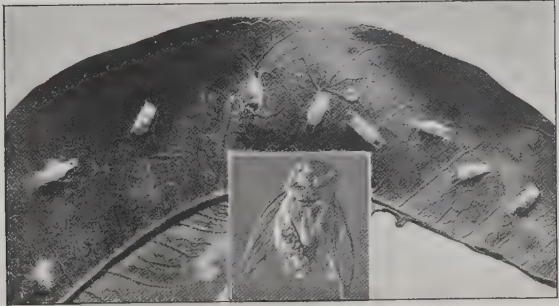
Parasites of Mango Leaf-hoppers (*Idiocerus* spp.).

- Fig. 1. Lower surface of mango leaf, showing dead hoppers after the *Pipunculus* larvae have emerged from them.
- „ 2. Full-grown larva of *Pipunculus annulifemur*.
 - „ 3. Mango leaf with cocoons of *Epipyrops fuliginosa*.
 - „ 4. Adult hopper with larva of *Epipyrops* attached to its side.
 - „ 5. Abdomen of a hopper, showing the Styloid parasite *in situ* with the triungulins inside it. (The specimen was boiled in caustic potash.)
 - „ 6. Abdomen of a hopper with the male puparia of the Styloid projecting from it.
 - „ 7. Hopper nymphs, showing larvae of the Dryinid parasites attached to the thorax.



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Parasites of the Mango Leaf-hoppers.

SOME NEW INJURIOUS PHYTOPHAGA FROM AFRICA.

By G. E. BRYANT,

Entomological Assistant, Imperial Bureau of Entomology.

Family CRIOCERIDAE.

***Crioceris viridissima*, sp. n. (fig. 1).**

Subcylindrical, brilliant metallic green to coppery green, with legs and three last ventral segments fulvous, and a large fulvous spot on vertex of head.

Length, 6 mm.

Head about as broad as prothorax, brilliant metallic green, with scattered punctures and a large fulvous patch on vertex, sulcate between the eyes on apical half of fulvous patch. *Antennae* stout, with first four joints with a slight metallic tinge, the seven apical joints dull black. *Prothorax* brilliant metallic green, slightly longer than broad, sides slightly rounded, strongly punctate, with a fovea at middle near base. *Scutellum* triangular, green. *Elytra* brilliant metallic green, punctate-striate, slightly shagreened, more than twice as long as broad, parallel-sided and rounded at apex, broader than base of prothorax. *Legs* fulvous, anterior pair in the ♂ with the tibiae more bent inwards than in ♀. *Underside* with sternum metallic green, rugosely punctured; ventral segments of abdomen with the first two metallic green, apical segments fulvous, sometimes showing traces of metallic green, and apical margin of second fulvous, with rather long scattered pubescence on all the segments.

KENYA COLONY: Nakuru, 4.xi.1918, 7 specimens (*S. Colclough*); Migori Valley, S. Kavirondo, 4,200 ft., v.1911, 1 specimen (*S. A. Neave*).

Specimens were forwarded by Mr. T. J. Anderson, Chief of Division of Entomology, Kenya Colony, with the information that they were attacking asparagus.

This new species is a true *Crioceris*, approaching in structure more nearly to European forms such as *C. 14-punctata*, Scop., than any African species at present described. It is probably most nearly allied to *C. nigropunctata*, Lacord., from South Africa, amongst the African species.

Family HALTICIDAE.

***Cercyonia citri*, sp. n. (fig. 2).**

Elliptical, convex, black or bluish-black, nitid; head and thorax finely punctured; elytra bluish-black, with a fulvous patch on basal half of each, punctate-striate; underside fulvous, legs darker. *Length*, 4-5 mm.

Head black, finely punctured, with two fulvous spots at base touching anterior margin of thorax. *Antennae* inserted wide apart near the inner circumference of the eyes, reaching just beyond base of thorax, first four joints fulvous, joint 1 equal to 2 and 3 combined, 5-10 more triangular, with apical half of each darker, apical joint acuminate. *Prothorax* black, finely and evenly punctured, more than twice as broad as long, with sides margined (margin in some fulvous) and narrowed towards apex; anterior angles produced and acute, posterior margin broadly produced at the middle. *Scutellum* triangular, black (in some reddish). *Elytra* bluish-black, very little broader than base of thorax, about three times as long as thorax, subcylindrical and narrowed posteriorly; punctate-striate, more feebly towards apex,

with the intervals finely punctured; a fulvous patch on each extending from below shoulder to middle, not touching suture or lateral margin. *Legs* variable, fulvous to almost black, with femora darker; posterior pair incrassate; a small spine at apex of hind tibiae. *Underside* fulvous; sternum strongly punctured; first ventral segment more strongly punctured, the rest with scattered punctures and slightly pubescent.

Male with last ventral segment more sinuate.

Easily distinguished from *C. nigricollis*, Jac., by its larger size and markings, which are constant in over 200 specimens before me.

GOLD COAST: Aburi, 8.xi.1916 (*W. H. Patterson*); Ojesu, Ashanti (*A. E. Evans*).

Reported by Mr. W. H. Patterson, Government Entomologist, Gold Coast, as a serious pest of all young citrus plants, and widely distributed in the Colony.

***Argopistes oleae*, sp. n. (fig. 3).**

Rounded, convex; head and prothorax black, finely punctured; elytra yellow, with suture and lateral margins black, each with a black vitta; underside fulvous. Length, 4.50 mm.

Head nearly hidden in the prothorax, from base to between eyes black, finely punctured, front and clypeus flavous. *Antennae* inserted close together, first four joints flavous, first joint very long and nearly equal to the three following together,



Fig. 1. *Crioceris viridissima*, sp. n.

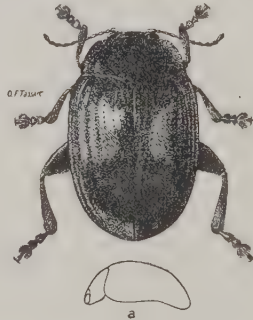


Fig. 2. *Cercyonia citri*, sp. n.;
a, lateral view.



Fig. 3. *Argopistes oleae*, sp. n.;
a, apex of hind tibia.

last seven joints slightly broader and fuscous. *Prothorax* strongly transverse, black, finely punctured, about three times as broad as long; sides obliquely converging and slightly rounded from base to apex, and deflexed; anterior angles obtuse and fulvous, posterior margin sinuate. *Scutellum* black, triangular. *Elytra* yellow, with sutural borders and lateral margins black, each with a black vitta extending almost from base to apex; finely punctured, longer than broad. *Legs*: front and intermediate pairs flavous, hind pair with the femora strongly incrassate, black with basal part flavous, their tibiae fulvous, broadly dilated, and deeply sulcate, dentate and terminated by two spurs (fig. 3, a); posterior tarsi with first joint longer than those of the front and middle pairs. *Underside* fulvous; ventral segments strongly punctured, with apical segment longer than the two preceding.

CAPE PROVINCE: 3 ♀♀, Cape Town, 9.iii.1918.

The larvae are recorded by the Division of Entomology, Pretoria, as mining in the leaves of olive trees.

This species is a remarkable mimic of the African Coccinellid genera, *Dysis* and *Alesia*.

***Argopistes sexvittatus*, sp. n. (fig. 4).**

Rounded, convex, testaceous; prothorax testaceous, finely and closely punctured; elytra fulvous, a little more strongly punctured than prothorax, sutural margin black, lateral margins broadly testaceous, with inner margin narrowly black from base of suture to apex, a narrow black vitta down middle of each elytron; underside fulvous. Length, 4.40 mm.

The ♂ only differs in its slightly smaller size and ventral segments, the last ventral being very large, strongly incised and deflexed, and longitudinally sulcate (fig. 4, *a*); the 2nd, 3rd and 4th segments are much contracted in the middle.

This species is closely allied to *A. oleae*, sp. n., but differs in having the head and prothorax testaceous, the elytral punctures are slightly stronger, the lateral margins are broadly testaceous, with the inner margins black, and the elytral vittae are narrower and more sinuate.

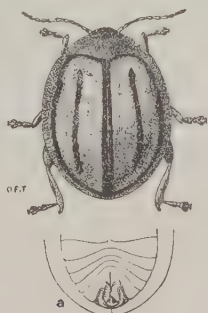


Fig. 4. *Argopistes sexvittatus*, sp. n.; *a*, venter.

CAPE PROVINCE: Stellenbosch, 11.x.1920, 2 ♂♂ and 1 ♀ on wild olive, 3 ♀♀ vars. (*Dr. C. K. Brain*). NATAL: Potgieter's Farm, i.1900, 1 ♀ (*H. Bell-Marley*). ORANGE FREE STATE: Bloemfontein, 6.ii.1916, 2 ♂♂, 4 ♀♀ (*J. C. Faure*).

The species is a leaf-miner on wild olive.

The six specimens from Bloemfontein do not vary *inter se*, but differ from the type from Stellenbosch in the black line of the lateral margins extending from the apex to little more than a third of the lateral margin. Three specimens collected by Dr. C. K. Brain at Stellenbosch, 11.x.1920, all females, have the elytra and prothorax blue-black, with a broad testaceous border. These are evidently only a variety of *A. sexvittatus*, as I can find no structural difference.

This species has stood in the British Museum collection since 1867 under the MS. name of *Pseudococcinella sexvittata*, Chevr., and I have thought it better to retain the specific name, as it has probably been widely circulated. This specimen came from the Hamlet Clark collection, which contained Chevrolat's collection.

NOTES ON THE LIFE-HISTORIES OF TWO MESOPOTAMIAN MOTHS.

By Rao Sahib Y. RAMACHANDRA RAO, M.A.,

*Assistant Entomologist, Agricultural College, Coimbatore.***Ocnerogyia amanda, Staud., a Pest of Figs.**

The following few notes are intended to supplement the excellent account of the life-history and habits of this insect already published by Mr. P. A. Buxton (Bull. Ent. Res. xi, pp. 181-186). Working as an Assistant Entomologist under the Agricultural Directorate at Baghdad, during the year 1919-1920, I had a few opportunities of observing this pest in Mesopotamia. I met with it in small numbers at Museyib on the Euphrates in June 1920, and at Karradah (a suburb of Baghdad) from June to the middle of September of the same year. It is evidently sporadic in its distribution; for I did not find it in gardens at Jadriyah, situated only three miles west of Karradah, nor did I notice it in any of the gardens at Hillah, which is situated on the Euphrates, about 25 miles south of Museyib.

The eggs are deposited in groups of 20 to 50 or more, being usually laid on the bark of the stems and less frequently on the underside of leaves. The egg is hemispherical in shape, and is attached by its convex face, while its distal face is flat and has a central depression. It is shiny yellow when freshly deposited, but soon becomes covered with dust. The larva when ready to hatch emerges by biting a large hole in the side of the egg.

The caterpillar when freshly hatched is less than 2 mm. long, light yellow in colour, and covered with light grey hairs. It passes through six moults before it becomes full-grown. A caterpillar that hatched on 18.vi.1920 went through the first moult on 20.vi.20, the second moult on 22.vi.20, the third moult on 24-25.vi.20, the fourth moult on 27-28.vi.20, the fifth moult on 1.vii.20, and the sixth moult on 4-5.vii.20. It began to build its cocoon on 11.vii.20, and finished it on 12.vii.20, but unfortunately died on the 13th July. Another caterpillar of the same batch, which hatched on 18.vi.20, began preparing its cocoon on 11.vii.20, pupated on 12-13.vii.20, and emerged as a moth on 20.vii.20. The larval period in these cases, therefore, covered about 24 days. The larva of the last or seventh instar is 22 to 28 mm. long; it is very hairy. The general coloration of the body is a soft greyish-brown, marbled with darker markings. The head is rugose and of an opaque pale brown. The prothoracic shield is not distinctly defined, but is broad and pale brown with a median stripe. On each side of the shield there is a prominent, anteriorly directed tubercle, carrying a conspicuous pencil of spines and hairs. A dorso-median streak of brownish-orange colour stretches from the head to the hind end. The trunk carries dorsally a number of tubercles, each bearing a bunch of spinelike bristles and long silky hairs—all of a greyish colour. The tubercles are disposed more or less as follows:—(1) A single dorso-lateral row; (2) a double row above the spiracles; and (3) another double row below the spiracles.

The larva feeds on the leaves during night-time, and hides in cracks in the soil or in crevices in the bark during the day. Occasionally, however, a few specimens may be found resting on the lower surface of leaves during the day. In the case under my observation at Karradah, most of the leaves were damaged to a greater or less extent, but the numbers of the pest were not large enough to cause entire defoliation.

The caterpillar seeks the ground when full-grown and constructs a loose silken cocoon (into which the hairs of the trunk are incorporated), in cracks of the soil or of mud walls close by.

The pupa is about 18 mm. long; stout and thickset, translucent grey when fresh, but turning yellowish-brown after a time. The anterior end is rounded and stout, while the posterior end is conical and terminates in an elongate spike-like process, carrying a bunch of recurved hooks at the tip. The wing rudiments reach almost to the edge of the fourth segment. Dorsally, both on the thorax and on the abdomen, groups of little chitinous tubercles—each carrying a fairly long curved grey hair—are noticeable. These form cushions of hair, which serve to support the pupa as it lies on its back in the cocoon. Similar cushions—but smaller in size and composed of shorter hairs—are found laterally and ventrally. The moth emerges in 8 to 11 days in summer, as may be seen from the table given below:—

<i>Pupated.</i>		<i>Emerged.</i>	<i>No. of days.</i>
(1)	12–13.vii.1920	∴ 20–21.vii.1920	∴ 8
(2)	19.vii.1920	∴ 30–31.vii.1920	∴ 11
(3)	22–23.vii.1920	∴ 30–31.vii.1920	∴ 8
(4)	23–24.vii.1920	∴ 31.vii.–1.viii.1920	∴ 8
(5)	23–24.vii.1920	∴ 1–2.viii.1920	∴ 9

The duration of the egg stage is not known, but probably varies from a week to 10 days in summer. Since the larval stage occupied about 24 days in the two cases under observation and the pupal stage covers 8 to 11 days, the entire life-cycle of the moth, from the time the egg is laid up to the time of the emergence of the moth, is about a month and a half. It is therefore probable that there are about three generations of the pest during the warmer part of the year, *i.e.*, from April to September. The insect probably hibernates as a larva in cracks in the soil or in crevices in the bark: and it is even not unlikely that it passes the winter in the egg-stage—considering the large size of the eggs. In the neighbourhood of Karradah the fig caterpillar was not known by any special name except by the general term "Dud-et-teen" (literally, the fig worm).

Banding the stems with tanglefoot might prove effective as well as economical in large gardens and deserves a trial in affected localities.

***Theretra alecto*, L., on Grape Vines.**

A light green shiny spherical egg—1.5 mm. in diameter—was noted on the 10th August 1920, laid on the upper surface of a leaf of a grape-vine, in the neighbourhood of the Government tree nurseries at Baghdad. On the 12th August the egg hatched into a slender greenish caterpillar, 3–4 mm. long, with the anal horn black and disproportionately long compared with the body. On the 14th August the first moult took place, and the second on the 17th. The caterpillar was observed growing rapidly, while the anal horn was noticed to become shorter after each moult. On the 20th August the third moult was gone through; dots were noted to have appeared on the sides of the trunk. On the 21st August the caterpillar measured about 37 mm., while on the 22nd the length was about 50 mm. On the 23rd August the fourth skin was cast and the spectacle-like markings were noted to have appeared. On the 25th August the larva of the fifth or last instar was about 60 mm. long, reddish-brown, thickset and cylindrical. The anterior part of the body was tapering, the head being opaque dark brown and small in proportion to the rest of the body. The segments of the thorax were narrower than those of the abdomen, but progressively increased in size from the front backwards. Segment 1 of the abdomen was the stoutest, and was marked dorsolaterally with a pair of large circular yellow-ringed black markings, having the appearance of a pair of eyes. A similar but smaller and less conspicuous pair of spectacles was noticeable on

segment 2. On segments 3, 4, 5 and 6 the spectacles were represented by elongate, oval, horizontal yellow patches. The sides of the body were yellowish-brown, with an oblique brown fascia on each segment. The anal horn was 2.5 mm. long, blunt-tipped, and pinkish-brown in colour. The true legs were pinkish with white bands, while the prolegs were thick, fleshy and purplish-brown in colour.

On the 28th August the larva ceased to feed and began to construct its cocoon, which was prepared of leaves and a loose network of a few strong silken strands, at the bottom of the cage. Under natural conditions the caterpillar presumably constructs its cocoon in the soil. It pupated during the night of the 30th August. The pupa was about 2 in. in length, elongate and cylindrical, varying in colour from a yellowish-brown to a darker brown. Head large; rudiments of eyes and antennae clearly impressed: face compressed, prominent and projecting a long way in front of the eyes. The rudiments of the wings, legs and proboscis extended almost to the posterior margin of the fourth abdominal segment. Abdomen tapering behind, terminating in a spike-like chitinous process carrying two strong hooks at the tip; spiracles large. The moth emerged on the 15th September 1920, being a large insect, pinkish-brown in colour, with the hind wings and sides of the abdomen rosy red.

The duration of the larval period in the present case was about 19 days, while the pupal period lasted about 15 days. In a second case, a caterpillar collected in October 1919 pupated in November 1919, passed the winter in the pupal stage, and emerged as a moth on the 9th May 1920.

This insect is found on the grape-vine in spring as well as in autumn, but is usually not seen in large numbers. It is, however, a voracious feeder, a similar caterpillar kept in a breeding cage having been found to have devoured nearly 100 vine leaves by the time it commenced to build its cocoon.

An allied hawkmoth, *Deilephila livornica*, is reported by Herr Bredemann to be a serious pest in vineyards in Upper Mesopotamia (Rev. App. Ent. viii, A, p. 346).

ON THE EGGS AND OVIPOSITION OF *PSOROPHORA* (*JANTHINOSOMA*)
POSTICATA, WIED. (CULICIDAE).

By J. L. PAWAN, M.B., Ch.B.,
Trinidad, British West Indies.

(Plate XVII.)

The mosquito, *Psorophora posticata*, Wied. (*Janthinosoma musica*, Say), commonly deposits its eggs in the rain-water that accumulates in the broken cacao pods strewn in heaps about the cool shady parts of cacao fields.

The ovipositing female assumes a characteristic attitude upon the surface of the water. The hind pair of legs lie extended backwards to their maximum length and slightly outwards. The front pair of legs are projected forwards and outwards, the femur forming almost a right angle with the tibia and the latter an obtuse angle with the tarsus, which rests forwards and outwards. In both the front and hind legs the tarsi are the only parts in direct contact with the surface of the water. The position of the middle pair of legs is very definite; the femur is directed backwards, the tibia is acutely flexed forwards and its apex embraces firmly the lateral borders of the egg-mass, the tarsus projecting sharply backwards and resting upon the surface of the water. Whilst the coherency of the egg-mass is maintained by the grip of the middle tibiae, the buoyancy of the eggs prevents the mosquito from being submerged during the process of oviposition. This process, which usually takes place in the morning, lasts from two to four hours, during which time the insect seems quite helpless, being unable and unwilling to take wing if disturbed, rendering herself an easy captive, and giving one the impression of being in pain. After oviposition has ceased the mosquito continues to rest upon the surface of the water, often away from the egg-mass, for from two to three hours, then crawls to the side of the containing receptacle and flies away.

The eggs lie in circular or subquadrate masses, consisting of from 25 to 40 in number, floating with their long axes perpendicular to the surface of the water and glued together at their broadest circumference by a gelatinous substance that helps to keep the mass afloat. A little less than one-third of their length is submerged. The eggs on escaping from the female are of a distinct greyish-brown colour, but in less than half an hour that portion which is exposed to the air assumes a dark steel-blue appearance, the whole mass of individual eggs simulating a honeycomb.

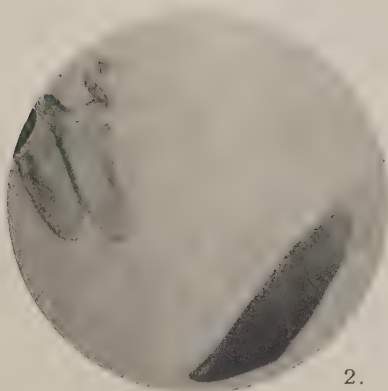
To the naked eye an individual egg (Pl. xvii, fig. 1) shows an ovoid shape elongated at both extremities, with the greatest circumference immediately above the junction of the blue and brownish portions, the latter tapering rapidly with a sharp and distinct curve. The lower portion, which retains its colour, is chitinous, while that which lies above the water is brittle and calcareous.

Under the microscope the portion of the egg that rests above the surface of the water is seen to be covered with a definite but loosely adherent capsule, studded with numerous translucent pedunculated and sessile tubercles, arranged in regular rows and containing air (Pl. xvii, fig. 2). This investing capsule does not extend beneath the water, and is also absent from a narrow triangular area on the upper two-thirds of the egg. Along this bare area the brown egg-shell can be seen, for the change in colour from brownish to dark blue affects the capsule only and not the egg-shell. Shorn of its capsule the underlying egg-shell is seen to consist of a brownish outer layer made up of definite circular strands, enclosing an inner thin delicate layer surrounding the yolk substance, which bathes the nucleus and subsequently the embryo. No operculum can be seen.

The larva hangs with its head downwards in the floating egg, and in from eight to ten hours after oviposition ruptures the lower submerged portion and the longitudinal area of the egg free from investing capsule and then escapes into the water.



1.



2.



3.

Fig 1. Eggs of *Psorophora posticata*, Wied.

Fig.2. Egg capsules; note the rows of spikelets.

Fig.3. Egg shells with capsules, after escape of larvae.

COLLECTIONS RECEIVED.

The following collections were received by the Imperial Bureau of Entomology between 1st October and 31st December 1921, and the thanks of the Managing Committee are tendered to the contributors for their kind assistance :—

Dr. W. M. ADERS, Government Economic Biologist :—50 Psocidae ; from Zanzibar.

Mr. T. J. ANDERSON, Chief Entomologist :—73 Siphonaptera, 4 Coleoptera, 11 Mallophaga, 136 Anoplura, 389 Mites, and 15 Ticks ; from Kenya Colony.

Dr. G. ARNOLD :—6 Asilid Flies ; from Rhodesia.

Mr. E. BALLARD, Government Entomologist :—55 Hymenoptera, 220 Coleoptera, 236 Rhynchota, and 116 Orthoptera ; from South India.

Mr. H. A. BALLOU, Entomologist, Imperial Department of Agriculture :—14 Parasitic Hymenoptera, 23 Coleoptera and early stages, 37 species of Coccidae, 1 species of Aleurodidae, and 1 Cimicid bug ; from the British West Indies.

Mr. H. W. BEDFORD :—64 Coleoptera, 8 Lepidoptera, 5 Crickets, and 1 tube of Red Spiders on cotton leaves ; from the Sudan.

Mr. C. F. C. BEESON, Forest Zoologist :—72 Curculionidae, and 130 Orthoptera ; from India.

Mr. G. E. BODKIN, Government Economic Biologist :—132 Culicidae, and 1 Hippoboscid fly ; from British Guiana.

Mr. H. E. BOX :—60 Chalcids, and 12 Coleoptera and early stages ; from Kenya Colony.

Dr. H. BRAUNS :—1 Nemestrinid fly and 33 Coleoptera ; from Cape Colony.

Mr. P. A. BUXTON :—4 *Leptoconops*, 6 Tabanidae, 22 other Diptera, 53 Coleoptera, 1 Microlepidopteron, 1 species of Coccidae, 37 other Rhynchota, 160 Orthoptera, and 1 *Chrysopa* ; from Palestine.

Dr. A. E. CAMERON :—19 Culicidae, 14 *Simulium*, 46 Tabanidae, 8 other Diptera, and 5 tubes of early stages ; from Canada.

Mr. L. C. COLEMAN, Director of Agriculture, Mysore :—10 Diptera and 4 pupae-cases, 6 Moths, and 12 Rhynchota ; from India.

Mr. R. E. COOPER :—A species of gall on *Indigofera* ; from Burma.

Mr. E. CRESSWELL-GEORGE :—4 Coleoptera, 1 Lepidopterous larva, and 3 Rhynchota ; from Nyasaland.

Mr. M. T. DAWE :—2 Tabanidae and 32 *Glossina* ; from Portuguese West Africa.

DIVISION OF ENTOMOLOGY, Pretoria :—50 Coleoptera ; from South Africa.

Mr. C. C. GOWDEY, Government Entomologist :—3 Diptera, 25 Parasitic Hymenoptera, 3 Coleoptera, 5 Lepidoptera, 1 species of Coccidae, 1 species of Aphididae, and 3 other Rhynchota ; from Jamaica.

Mr. H. HARGREAVES, Government Entomologist :—1 Mosquito, 7 Tabanidae, 77 other Diptera, 41 Hymenoptera, 308 Coleoptera, 98 Lepidoptera, 1 Ant-lion, 319 Rhynchota, 70 Orthoptera, and 1 tube of Mites parasitic on a Gryllid ; from Uganda.

Mr. G. F. HILL, Entomologist, Australian Institute of Tropical Medicine :—2 Hymenoptera and nest, 5 Coleoptera, 2 Lepidoptera, 3 Rhynchota, 6 Orthoptera and 3 nymphs, 7 Spiders, 1 Centipede, and 1 Millipede ; from Australia.

Capt. HINGSTON :—10 Crickets ; from United Provinces, India.

Mr. M. AFZAL HUSAIN, Government Entomologist :—500 Parasitic Hymenoptera and 4 Rhynchota ; from the Punjab.

Mr. R. W. JACK, Chief Entomologist, Department of Agriculture :—2 Coleoptera ; from Rhodesia.

Dr. W. B. JOHNSON :—5 *Haematopota*, 3 *Tabanus*, 36 *Glossina*, and 5 other Diptera ; from N. Nigeria.

Mr. H. H. KING, Government Entomologist :—8 Dipterous larvae and 45 Orthoptera ; from the Sudan.

Mr. N. C. E. MILLER :—85 Hemimeridae ; from Tanganyika Territory.

Prof. S. A. MOKRZECKI :—5 Coleoptera ; from Bulgaria.

Mr. J. C. MOULTON :—2 Coccinellidae and 1 pupa, and 31 Orthoptera ; from Singapore.

Mr. F. MUIR :—138 Curculionidae and 3 Rhynchota ; from Fiji and Honolulu.

NATAL MUSEUM :—403 Orthoptera ; from South Africa.

Mr. W. H. PATTERSON :—10 Diptera ; from the Gold Coast.

Dr. L. PÉRINGUEY, Director of the South African Museum :—176 Orthoptera ; from South Africa.

Mr. A. W. J. POMEROY, Government Entomologist :—185 Mosquito larvae, 35 Nycteribiidae, 50 Coleoptera, 71 Lepidoptera, 1 Thysanopteron, 4 Isoptera, 3 Planipennia, 5 Orthoptera, 3 Odonata, 3 Lice, 40 Ticks, and 4 Worms ; from Nigeria.

Mr. A. H. RITCHIE :—4 Curculionidae ; from the Suez Canal : 1 species of Aleurodidae ; from Kenya Colony : and 8 Coleoptera ; from Tanganyika Territory.

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